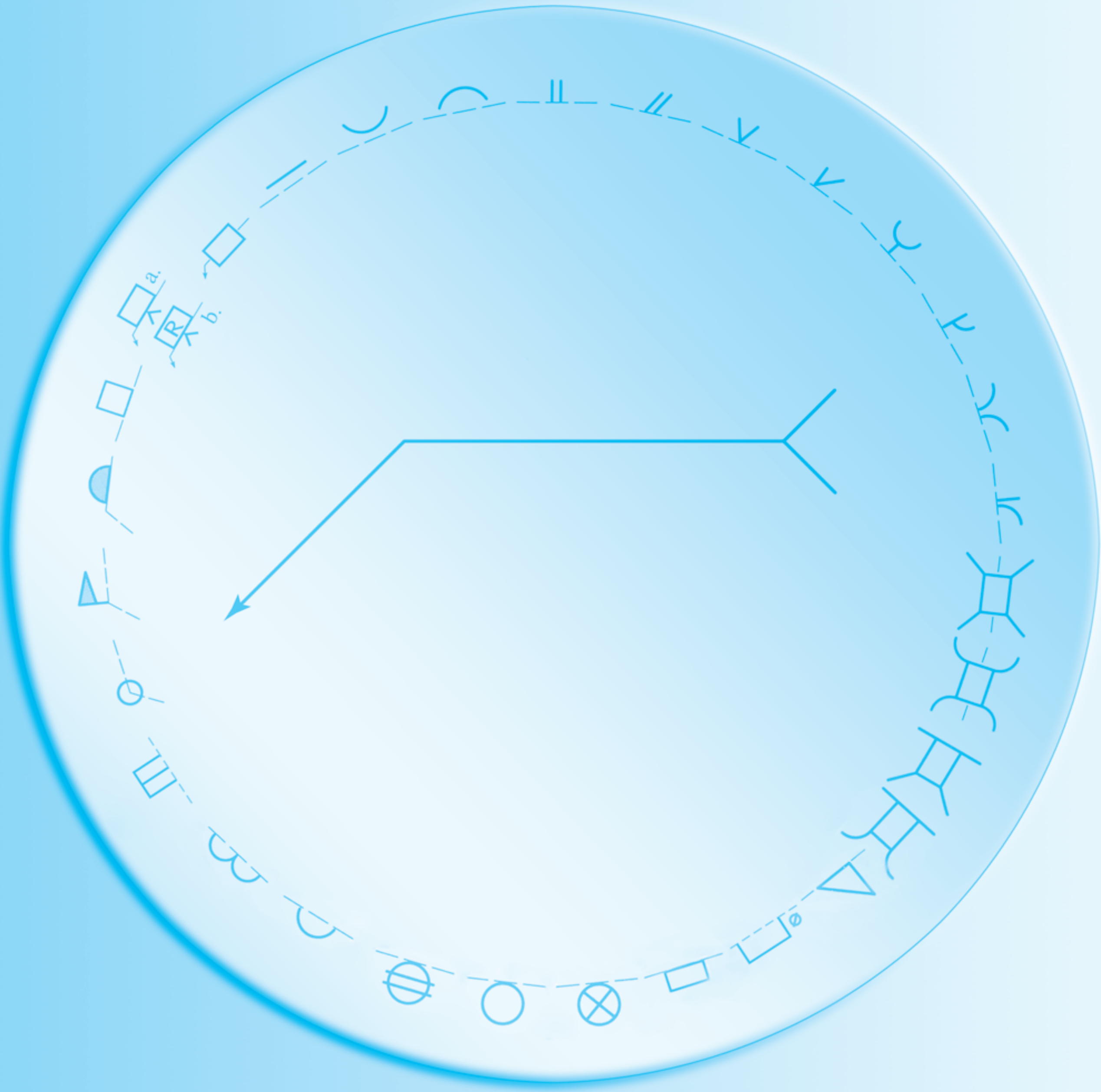
BLUEPRINT READING FOR WELDERS

8th Edition



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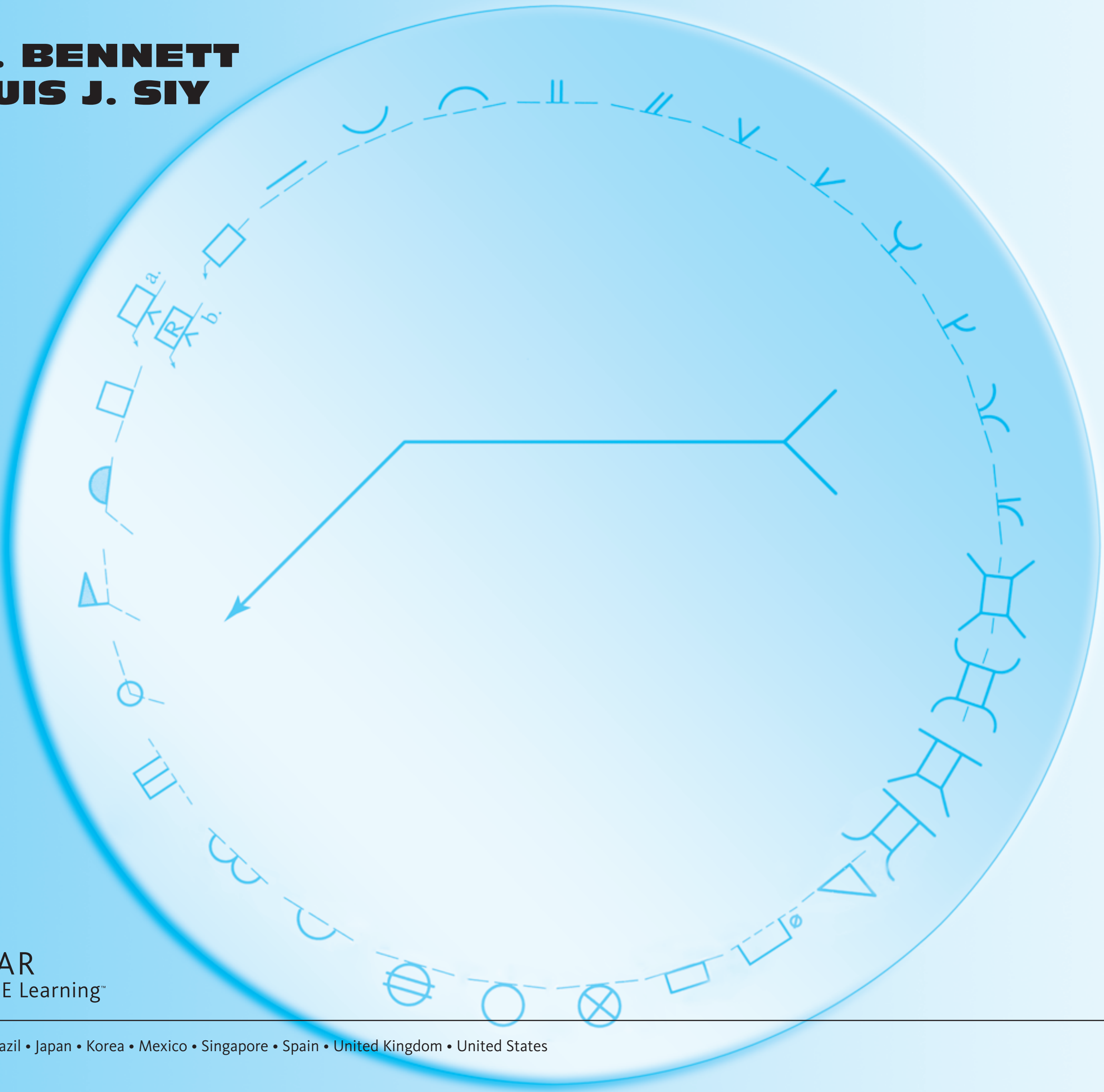
BLUEPRINT READING FOR WELDERS

8th Edition

A. E. BENNETT
LOUIS J. SIY



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PREFACE

The eighth edition of ***Blueprint Reading for Welders*** provides detailed information to help students develop skills necessary to interpret working sketches and prints common to the metalworking field.

The engineering drawing is the medium by which the engineer/designer and drafter convey information to welders, machinists, and other related trades. To use the drawing, the welder is required to understand both conventional drafting symbology and specialized welding symbols. The ability to interpret the drawing is a skill that welders must develop through repeated practice. The text provides ample opportunity for such practice through the end of unit review assignments.

Information on the purpose and makeup of prints is taught in easy-to-follow steps. The text begins with simple drafting concepts and sketching techniques, then covers the metal structural shapes commonly used by welders. More advanced drafting techniques are described, including auxiliary views; detail views; projections; and sections, detail, and assembly drawings. Once the learner is familiar with the basic drafting concepts and components of drawings, the American Welding Society standard weld symbols are introduced. A substantial part of the text then examines each weld symbol, its representation on a drawing, dimensioning requirements, and specific meaning in different situations. An entire unit is devoted to explaining basic joints for weldment fabrications. Other topics explained in detail include pipe welding symbols and their application, applied metrics and dual dimensioning, nondestructive examination symbols, bills of materials, international standard symbols (ISO) for welding, first-angle and third-angle orthographic projection, geometric dimensioning and tolerancing, and computer-aided drafting.

The appendix section includes updated specification sheets for structural metal shapes, including pipes, and tables for converting decimal, fractional, and whole inches to millimeters.

Folded, tear-out drawings at the back of the text reproduce selected assignment drawings in a larger size for ease of interpretation. The large size drawings also include drawings for the comprehensive test provided in the Instructor's Guide.

Content changes for the eighth edition include:

- Terminology and weld symbol revisions.
- Additional problems for selected units.
- Additional prints with related problems.

INSTRUCTOR E.RESOURCE

This is an educational resource that creates a truly electronic classroom. It is a CD-ROM containing tools and instructional resources that enrich your classroom and make the instructor's preparation time shorter. The elements of e.resource link directly to the text and tie together to provide a unified instructional system. With e.resource, you can spend your time teaching, not preparing to teach. ISBN: 1-4283-3530-7

Features contained in e.resource include:

- **Instructor's Guide:** Answers and solutions to end-of-unit review questions and problems are provided.
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- **Handouts:** These handouts can be printed or viewed electronically to describe and graphically represent the concepts of first-angle, third-angle, and oblique projection.

The eighth edition of *Blueprint Reading for Welders* continues a dedicated tradition of providing the most comprehensive treatment of AWS, ISO, and pipe welding and their interpretation.

INSTRUCTOR'S GUIDE

An Instructor's Guide is available for the text. It contains an explanation on how to use the text book and answers to end of unit review questions. ISBN: 1-4283-3529-3

WELD SYMBOLS WHEEL

Included in this text is a 2-sided plastic Weld Symbols Wheel written in English and Spanish, listing 30 types of welds by name and symbol, Type of Test and Symbol, and letters used with contour symbols to indicate method of finish. If you would like to purchase the Weld Symbols Wheel separately, the ISBN for ordering is 1-4354-8325-1.

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American Society of Mechanical Engineers

American Welding Society

International Standards Organization

American Society of Mechanical Engineers

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THE PURPOSE AND MAKEUP OF PRINTS

The calculations and ideas of the engineer must be transferred to the welder working in the shop or on a job site. It is usually impractical for an engineer to be present while a weldment is being fabricated. Therefore, the needed information must be supplied by some method other than verbal communication. The most concise method for doing this is through the use of detail drawings.

When drawings are prepared manually, they are usually made directly on tracing paper or plastic that is then used for making prints in the quantities needed. However, the most current method for the production of prints is through the use of computers. This latter method is called Computer Aided Drafting (or Design) and is abbreviated as CAD. Using the information "drawn" with the computer, "hard copies" of drawings are printed on paper at very high speeds. The proper use of CAD requires a knowledge of blueprint reading and welding symbols. (For more information see Unit 27.)

There are three basic elements to be found on a print: **lines**, **dimensions**, and **notes** (as shown in Figure 1). Lines show the edges of the object, aid in dimensioning the object, and are used in the formation of symbols. Dimensions give sizes and locations. Notes, giving details of construction not shown by lines, may be in the form of symbols or abbreviations. A note that designates the kind of material, machining process, or standard to be used is often referred to as a specification. Notes or specifications are found adjacent to a view or in a ruled space provided on the print for this purpose.

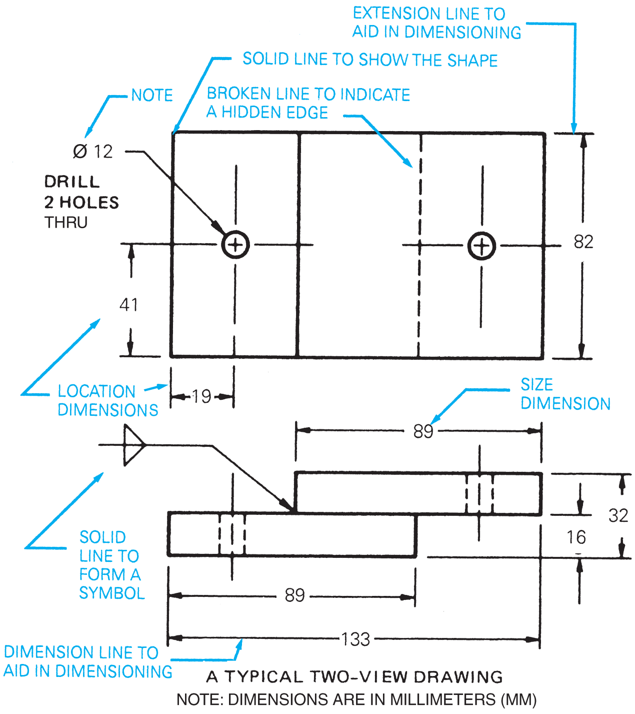
EXTENSION LINE TO AID IN DIMENSIONING
SOLID LINE TO SHOW THE SHAPE
NOTE
BROKEN LINE TO INDICATE A HIDDEN EDGE
Ø 12
DRILL
2 HOLES
THRU
82
41
LOCATION DIMENSIONS
19
SIZE DIMENSION
89
32
16
SOLID LINE TO FORM A SYMBOL
89
133
DIMENSION LINE TO AID IN DIMENSIONING
A TYPICAL TWO-VIEW DRAWING
NOTE: DIMENSIONS ARE IN MILLIMETERS (MM)

FIGURE 1 ■ A typical two-view drawing.

A print consists of one or more views, usually the **top**, **front**, and **right side** views of the object. Other views that may be used to describe the object completely are the left side, back, auxiliary, and bottom views. The number and type of views to be shown depend on the shape and complexity of the object. A concept of these views is presented in the units that follow.

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UNIT 1

Basic Lines and Views

BASIC LINES

There are several different types of lines used on a print and each has a different meaning. To be able to interpret a print, the reader should have knowledge of these lines. Table 1.1 can be used as a reference for the common line types usually found on a print. Note that the purpose of each line deals with either the shape of the object or its dimensioning.

BASIC VIEWS

Drawings are made to describe the object in sufficient detail to permit fabrication. Orthographic projection is the method employed to do this. By this method the exact form of the object is shown by various views of the object arranged in a particular order. The selection and arrangement of these views is shown in Figure 1.2. Note the relationship in the placement of the views in the figures.

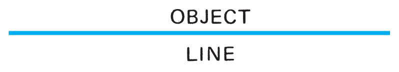
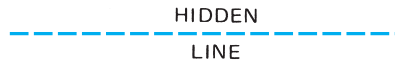
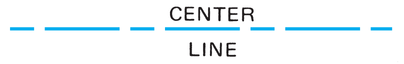
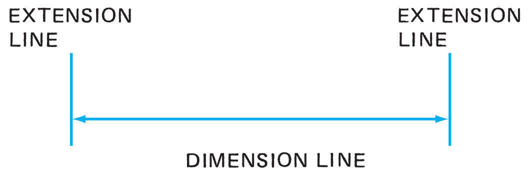
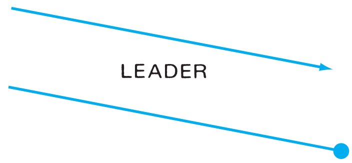
Type of Line	Description	Purpose
 OBJECT LINE	Thick solid line.	To show the visible shape of a part (outline of object).
 HIDDEN LINE	Broken line of medium thickness.	To show edges and outlines not visible to the eye.
 CENTER LINE	Fine, broken line made up of a series of short and long dashes alternately spaced.	To show the center of circles, arcs, and symmetrical objects and to aid in dimensioning these parts.
 EXTENSION LINE EXTENSION LINE DIMENSION LINE	Extension lines are fine lines that extend from the object with a slight break between. Dimension lines are fine lines with arrowheads, unbroken except where the dimension is placed.	Extension lines show dimensioning points. Dimension lines touch the extension lines and show distance given by the dimensions.
 LEADER	Fine, straight line with an arrowhead or round solid dot at one end. It is usually drawn at an angle.	Points directly to a surface for the purpose of dimensioning or adding a note. A dot is used at the end of the straight line where reference is made to a surface area.

TABLE 1.1 ■ Common types of lines used on a print. (continued)

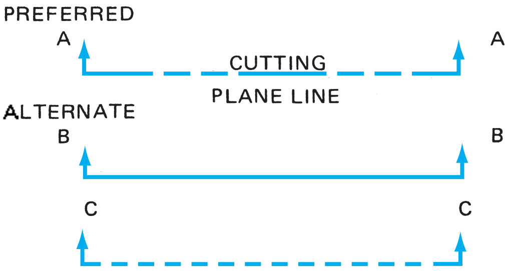
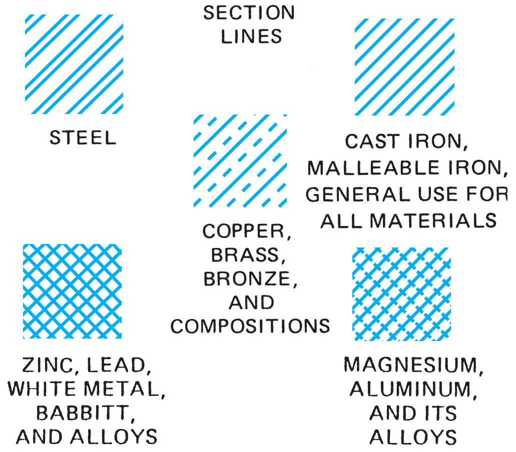
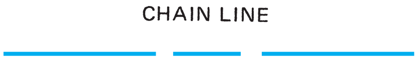
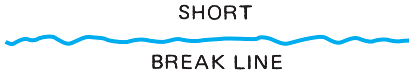
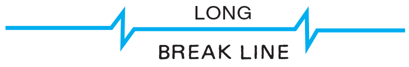
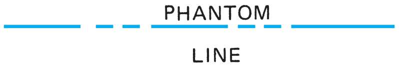
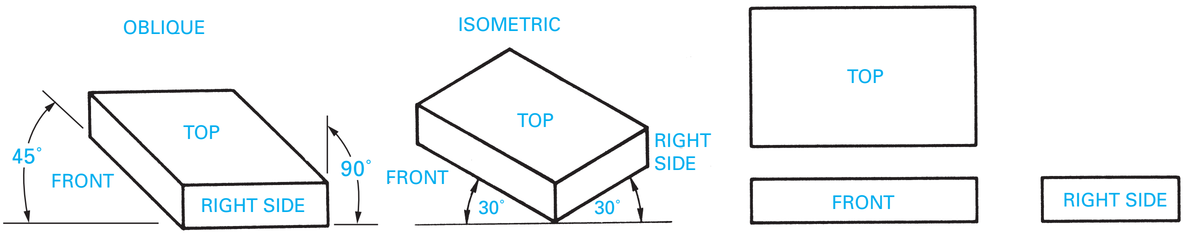
Type of Line	Description	Purpose
 PREFERRED A A CUTTING PLANE LINE ALTERNATE B B C C	The preferred cutting plane line is a heavy, broken line made up of a series of one long and two short dashes alternately spaced. Arrowheads are placed at right angles to the cutting plane line as shown. Alternate cutting plane lines are a solid heavy line or a series of long dashes.	To indicate where an imaginary cut is made through the object. The arrow points in the direction in which the section should be viewed. Letters next to the arrowheads identify the section in cases where more than one section is shown on the drawing. These lines are oriented vertically, horizontally, or at the actual angle at which the part is drawn.
 SECTION LINES STEEL CAST IRON, MALLEABLE IRON, GENERAL USE FOR ALL MATERIALS COPPER, BRASS, BRONZE, AND COMPOSITIONS ZINC, LEAD, WHITE METAL, BABBITT, AND ALLOYS MAGNESIUM, ALUMINUM, AND ITS ALLOYS	Series of fine lines—solid or solid and broken—arranged in specific patterns. They may be shown either straight or curved. When shown straight, they are usually drawn at a 45° angle. However, this angle will vary when applied to adjacent parts.	To indicate the imaginary cut surface referred to by the cutting plane line; to represent various kinds of materials.
	Heavy, broken line made up of a series of long and short dashes alternately spaced.	Indicates the location and extent of a surface area.
	Heavy, irregular line drawn freehand.	To show a short break (to conserve space on a drawing); to show a partial section.
	Ruled, light line with freehand zigzags.	To show a long break (to conserve space on a drawing).
	Light, broken line made up of a series of one long and two short dashes.	To show alternate positions of a part; to show relationship of existing part to new part; to show machined surfaces.

TABLE 1.1 ■ Common types of lines used on a print. (concluded)

Figure 1.1(a) shows two types of pictorial drawings of a three-dimensional block and Figure 1.1(b) shows three two-dimensional views of the block. By examining each of the three views in Figure 1.1(b), an accurate picture of the shape of each face can be formed. In this case, three views are used to describe the object. Note that the views have a definite arrangement. The top view is placed directly above and in line with the front view; the right side view is placed to the right of and in line with the front view. This arrangement of views is in accordance with third angle orthographic projection referred to in Figure 1.1.

There is no limitation on the number of views that may be used to describe an object. Usually, three properly selected views are sufficient. In cases where more views are needed to illustrate the shape clearly and to make dimensioning easier, the bottom, left side, or back views can by used. Simple parts can be completely described with only one or two views.



(a) PICTORIAL

(b) ORTHOGRAPHIC PROJECTION (IN THREE VIEWS)

FIGURE 1.1 ■ Methods of representing an object.

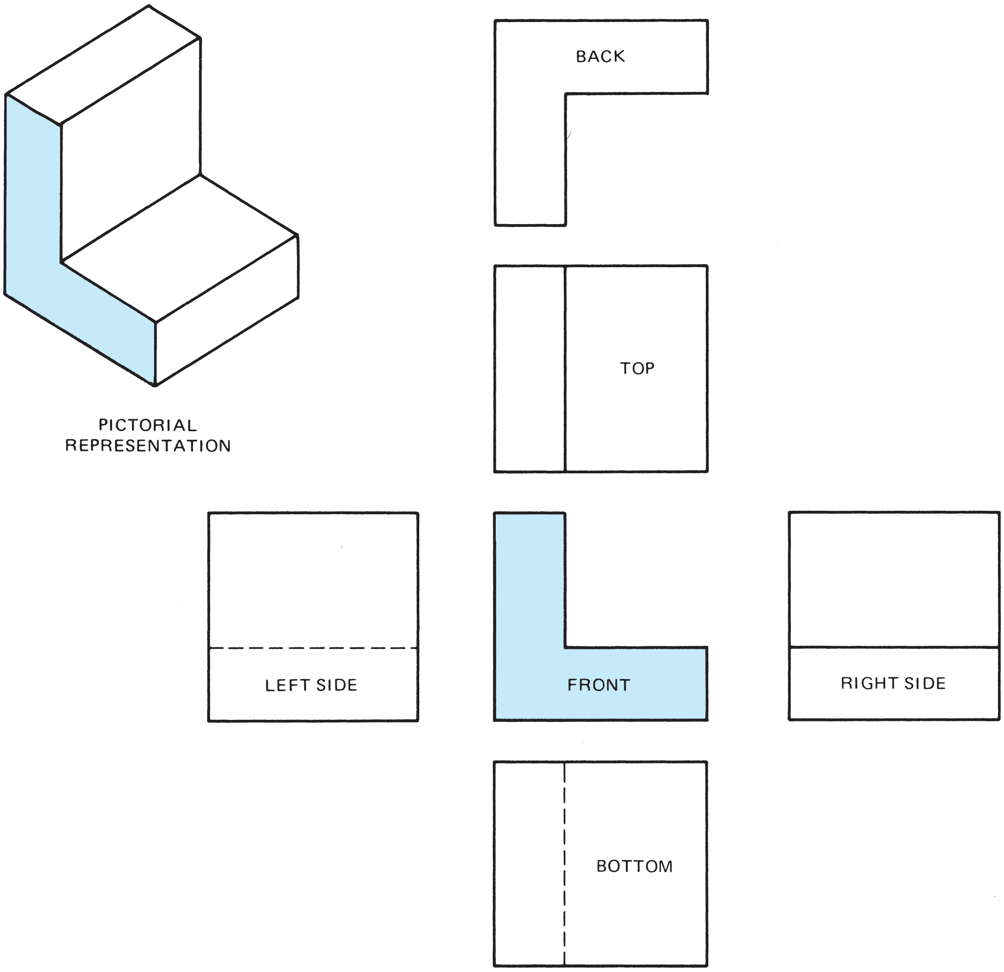
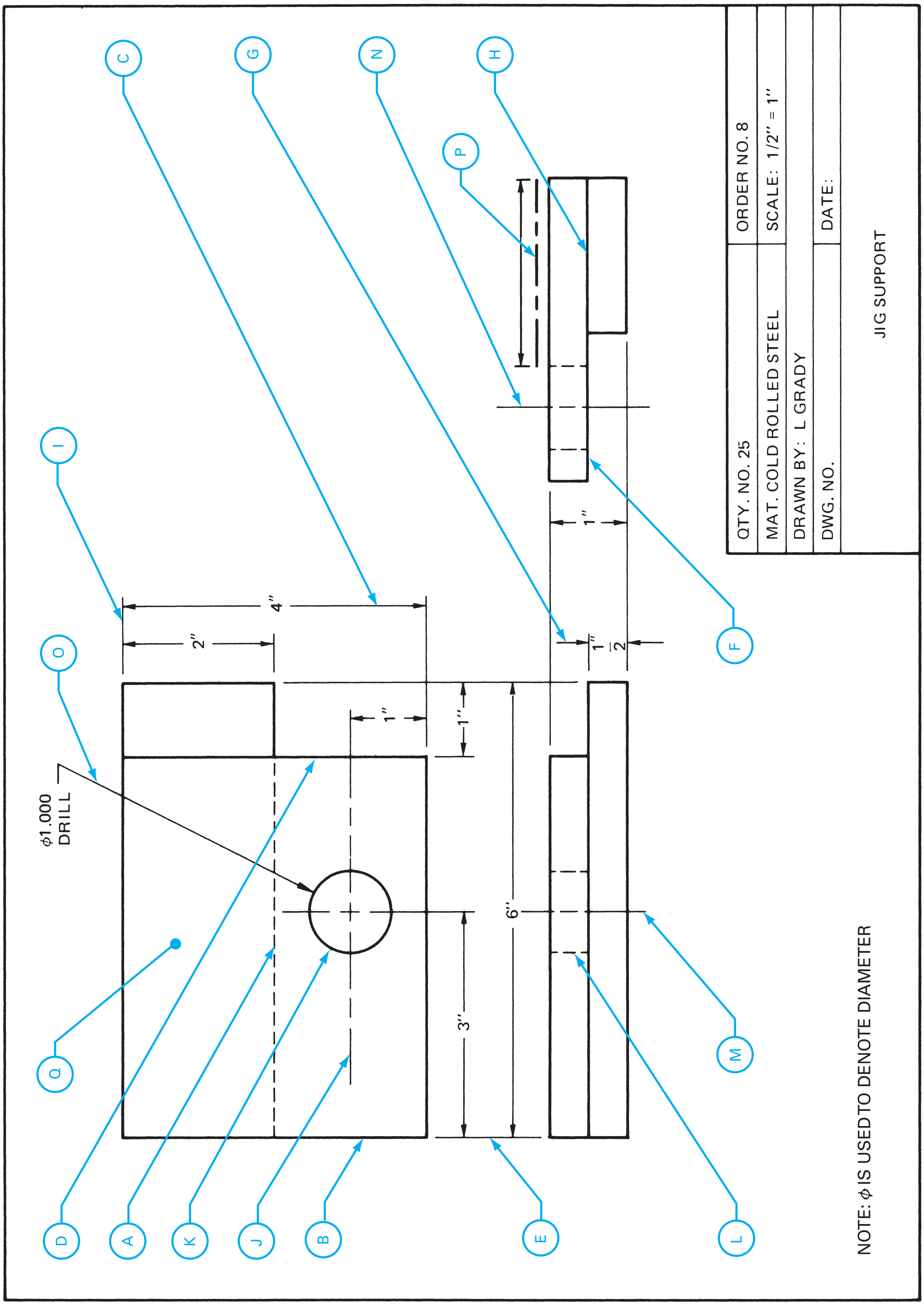


FIGURE 1.2 ■ Locations and alignment of views that may be selected to describe an object on an orthographic drawing.

It should be noted that the front view usually gives the best indication of the shape and detail of the object. This does not mean that the front view necessarily shows the front of the object. For example, if a welding torch is represented on a print, the front of the torch is not shown as the front view since it does not show the shape of the torch as well as a side profile of the torch. Therefore, to simplify the reading of the print, the profile selected for the front view is generally that which best describes the most detailed shape of the object.

All views have a particular position with respect to each other, and have either a horizontal or vertical alignment. These positions, illustrated in Figure 1.2, should be learned.



ϕ1.000
DRILL
2"
4"
1"
1"
6"
3"
1"
1"/2
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
QTY. NO. 25
ORDER NO. 8
MAT. COLD ROLLED STEEL
SCALE: 1/2" = 1"
DRAWN BY: L GRADY
DWG. NO.
DATE:
JIG SUPPORT
NOTE: ϕ IS USED TO DENOTE DIAMETER

UNIT 1: REVIEW A

Refer to the drawing, Jig Support, page 4.

1. a. Identify the following types of lines.

Ⓐ ____________________

Ⓑ ____________________

Ⓒ ____________________

Ⓓ ____________________

Ⓔ ____________________

Ⓕ ____________________

Ⓖ ____________________

Ⓗ ____________________

Ⓘ ____________________

Ⓙ ____________________

Ⓚ ____________________

Ⓛ ____________________

Ⓜ ____________________

Ⓝ ____________________

Ⓞ ____________________

Ⓟ ____________________

b. What does Ⓠ have reference to?

____

2. Give the function or functions of the following lines.

Ⓐ ____________________

Ⓑ ____________________

Ⓒ ____________________

Ⓔ ____________________

Ⓙ ____________________

3. Describe the lines shown on the drawing with reference to letters Ⓔ through Ⓟ.

Ⓔ ____________________

Ⓗ ____________________

Ⓒ ____________________

Ⓛ ____________________

Ⓜ ____________________

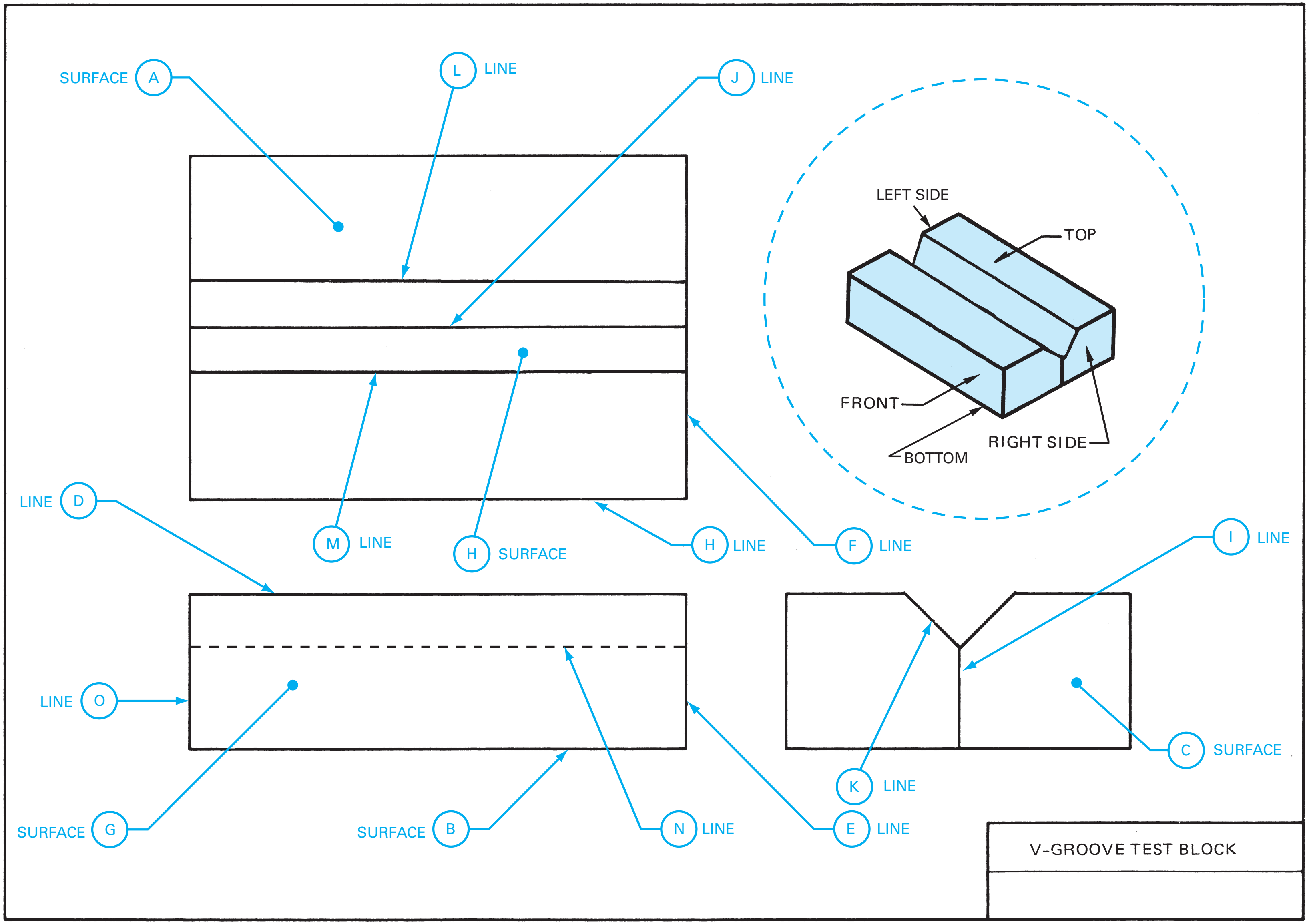
Ⓟ ____________________

4. a. Identify the kind of material specified to make the part.

____

____

b. Sketch the section line symbol that would be used for this material.


SURFACE A
L LINE
J LINE
LEFT SIDE
TOP
FRONT
RIGHT SIDE
BOTTOM
LINE D
M LINE
H SURFACE
H LINE
F LINE
I LINE
LINE O
C SURFACE
K LINE
SURFACE G
SURFACE B
N LINE
E LINE
V-GROOVE TEST BLOCK

UNIT 1: REVIEW B

Refer to the drawing, V-Groove Test Block, page 6.

1. Why are three views used to show the object?

2. Name each of the views shown.

3. In which two views is the length of the object the same?

4. In which two views is the width of the object the same?

5. In which views is the thickness of the object the same?

6. Which line represents surface Ⓐ in the front view?

7. Which line represents surface Ⓗ in the right side view?

8. Which line represents surface Ⓒ in the front view?

9. Which line represents surface Ⓒ in the top view?

10. Which line in the top view represents surface Ⓖ in the front view?

11. Is surface Ⓑ shown in the top view?

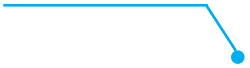
12. What does the top view have in common with the front view?

13. What does the front view have in common with the side view?

14. What do the top view and right side views have in common with respect to the front view in terms of alignment?

15. What do lines Ⓛ and Ⓜ represent?

16. What does the following symbol indicate?



17. Which line represents Ⓝ in the top view?

18. What surface does Ⓑ represent?

19. What surface does Ⓞ represent?

2 UNIT

Sketching

PURPOSE OF SKETCHING

A *sketch* is a freehand drawing used to describe the shape and size of an object. It is a means of quickly expressing an idea. If necessary, it can later be translated into a finished drawing.

Sketches are often used in place of finished drawings, particularly when time and circumstances do not permit preparation of a finished drawing. In such cases, the sizes of the objects in the sketches are drawn in relative proportion to one another. All of the details and data needed to shape or fabricate the part, including dimensions and notes, are added to the sketch.

BASIC SKETCHING TECHNIQUES

Sketching Lines

Lines are first lightly sketched with short overlapping strokes using a pencil with a fairly sharp point. The lines are then darkened and weighted in accordance with their purpose—in the same manner that lines are shown on a finished drawing. Heavy lines are drawn by dulling (rounding) the point of the pencil and applying enough pressure to produce the line weight desired. Refer to Unit 1, Table 1.1 for the kinds of lines used on a finished drawing.

Sketching Arcs, Circles, and Ellipses

One method for sketching an arc is to first construct a right angle (square corner). To assist in sketching the arc, guide points (R) are located on the legs of the angle to indicate where the curve is to begin and end. The points are then connected with a curved line, Figure 2.1. All unnecessary lines are erased after the sketch is completed.

Another method for sketching an arc also begins with a right angle. The two equidistant points (R) are then drawn. These points are connected with a diagonal line so that a triangle is formed. A dot is placed in the center of the triangle, and the arc is drawn so that the curved line connects all three points, Figure 2.2.

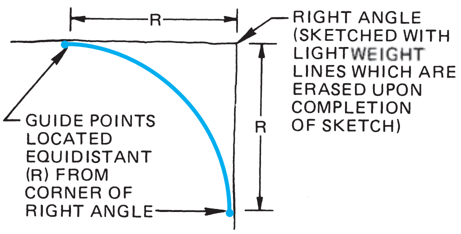

R
RIGHT ANGLE (SKETCHED WITH LIGHTWEIGHT LINES WHICH ARE ERASED UPON COMPLETION OF SKETCH)
GUIDE POINTS LOCATED EQUIDISTANT (R) FROM CORNER OF RIGHT ANGLE
R

FIGURE 2.1 ■ Using a right angle as a guide for sketching an arc.

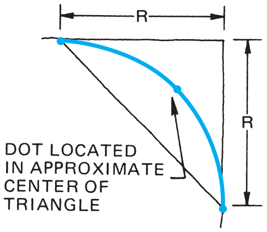


FIGURE 2.2 ■ Using a triangle as a guide for sketching an arc.

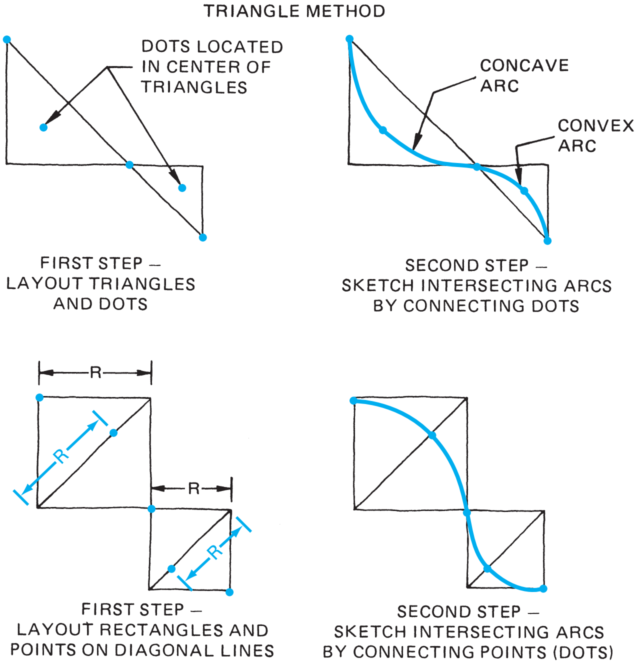

TRIANGLE METHOD
DOTS LOCATED IN CENTER OF TRIANGLES
FIRST STEP – LAYOUT TRIANGLES AND DOTS
CONCAVE ARC
CONVEX ARC
SECOND STEP – SKETCH INTERSECTING ARCS BY CONNECTING DOTS
R
R
R
R
FIRST STEP – LAYOUT RECTANGLES AND POINTS ON DIAGONAL LINES
SECOND STEP – SKETCH INTERSECTING ARCS BY CONNECTING POINTS (DOTS)

FIGURE 2.3 ■ Methods for sketching intersecting arcs.

To sketch arcs that change direction and meet at a common point (intersect), the procedure shown in Figure 2.3 is followed. Essentially, it is a matter of developing connecting arcs using a combination of any one of the techniques previously described. Note: The letter *R* is used to indicate a radius.

To sketch a circle, the same process for sketching an arc is repeated for all quarters of the circle. Either of the two methods described for sketching an arc may be applied to sketching a circle, Figure 2.4.

On some views of an orthographic drawing, a circle may appear as an ellipse. An ellipse is sketched by laying out a rectangle with sides equal to the major and minor axes of the ellipse, Figure 2.5. The rectangle is then divided into four equal quarters. The dividing lines represent the major and minor axes of the ellipse. Thereafter, the use of triangles, Figure 2.5(a), or rectangles, Figure 2.5(b), as guides permits sketching the ellipse in a manner similar to that for sketching a circle.

In addition to orthographic sketches, oblique or isometric drawings are often used to present an idea or design of a weldment. The latter two types of drawings are three-dimensional (pictorial) drawings, which may be shown alone or in conjunction with an orthographic drawing.

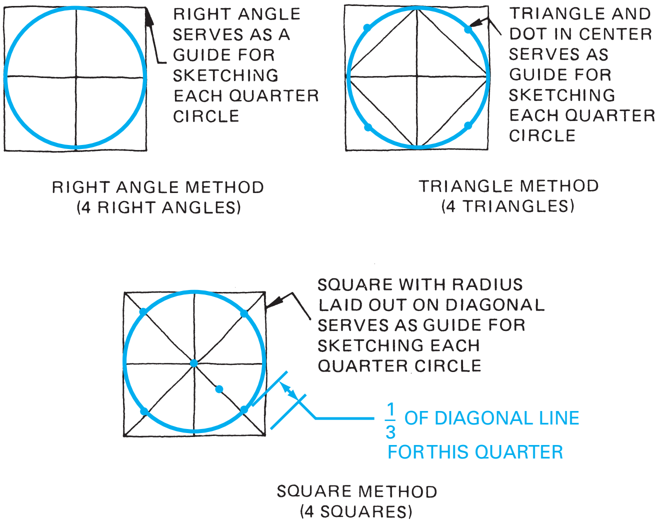

RIGHT ANGLE SERVES AS A GUIDE FOR SKETCHING EACH QUARTER CIRCLE
RIGHT ANGLE METHOD (4 RIGHT ANGLES)
TRIANGLE AND DOT IN CENTER SERVES AS GUIDE FOR SKETCHING EACH QUARTER CIRCLE
TRIANGLE METHOD (4 TRIANGLES)
SQUARE WITH RADIUS LAID OUT ON DIAGONAL SERVES AS GUIDE FOR SKETCHING EACH QUARTER CIRCLE
1/3 OF DIAGONAL LINE FOR THIS QUARTER
SQUARE METHOD (4 SQUARES)

FIGURE 2.4 ■ Techniques for sketching a circle.

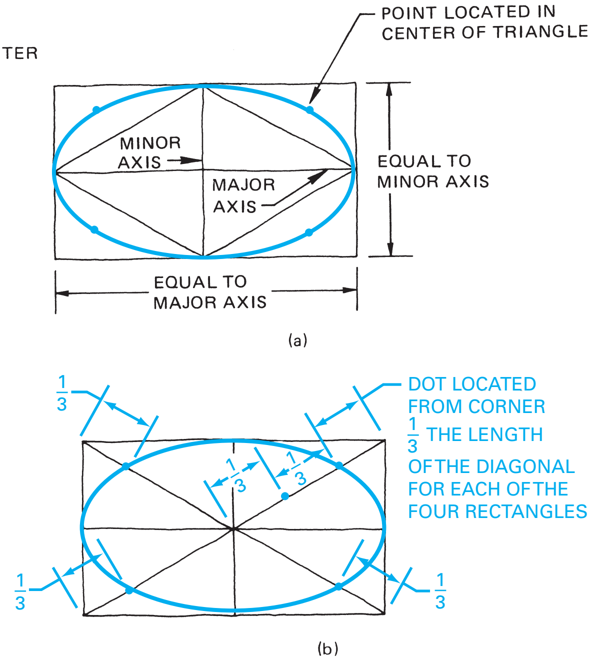

POINT LOCATED IN CENTER OF TRIANGLE
MINOR AXIS
MAJOR AXIS
EQUAL TO MINOR AXIS
EQUAL TO MAJOR AXIS
(a)
1/3
DOT LOCATED FROM CORNER 1/3 THE LENGTH OF THE DIAGONAL FOR EACH OF THE FOUR RECTANGLES
1/3
1/3
1/3
1/3
(b)

FIGURE 2.5 ■ Methods for sketching an approximate ellipse.

Oblique Sketching

To develop an oblique drawing, an orthographic view of the object is first drawn that best describes the shape and shows the most detail of the object. For example, the front view of the three-view orthographic drawing of the T-support shown in Figure 2.6 is selected since it shows the shape of the object best.

After completing the orthographic view, draw parallel receding lines at about 45° angles from the corners of the view (either to the right or to the left), as shown in Figure 2.7 and Figure 2.8, to develop the three-dimensional effect. Receding lines are drawn to the right for developing a right oblique drawing and to the left for developing a left oblique drawing. Lines are not usually shown for any part of the object that is not visible. The extent of the receding lines is about one-half the length that would be shown for an orthographic drawing. This is so that the sketch will appear to be true to the original form of the object. The oblique sketch is completed by repeating the same lines shown on the original orthographic view at the terminal points of the receding lines. Note that, on occasion, broken lines may be used to show hidden edges in order to better visualize the object.

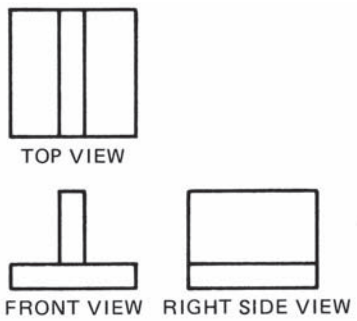


FIGURE 2.6 ■ Three-view orthographic drawing of a fabricated T-support.

Oblique sketches may require the sketching of oblique circles. Variations of oblique circles and how they may be constructed are shown in Figure 2.9. The procedure used for sketching the oblique circles shown in the oblique cube is the same as that given previously for developing a regular circle. Essentially, the procedure followed is to locate points on a rectangle to which a series of arcs is drawn to form the oblique circle.

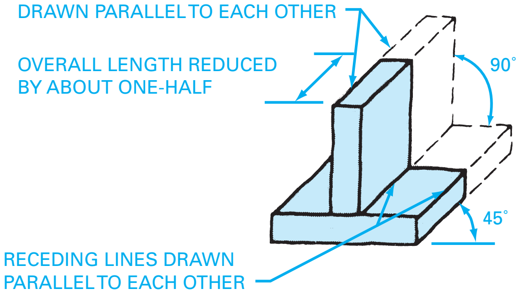

DRAWN PARALLEL TO EACH OTHER
OVERALL LENGTH REDUCED BY ABOUT ONE-HALF
90°
45°
RECEDING LINES DRAWN PARALLEL TO EACH OTHER

FIGURE 2.7 ■ Right oblique (receding lines drawn to right).

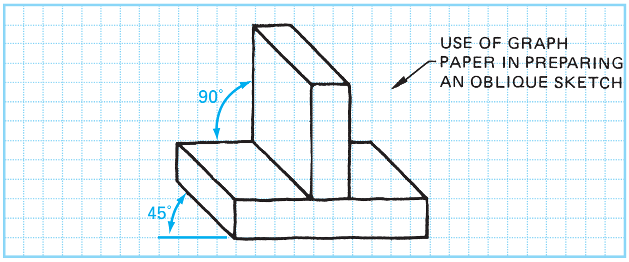


FIGURE 2.8 ■ Left oblique (receding lines drawn to left).

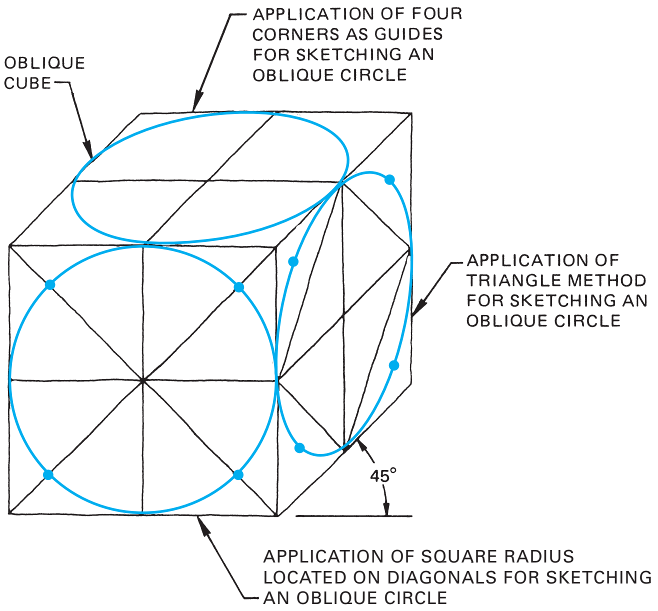

APPLICATION OF FOUR CORNERS AS GUIDES FOR SKETCHING AN OBLIQUE CIRCLE
OBLIQUE CUBE
APPLICATION OF TRIANGLE METHOD FOR SKETCHING AN OBLIQUE CIRCLE
45°
APPLICATION OF SQUARE RADIUS LOCATED ON DIAGONALS FOR SKETCHING AN OBLIQUE CIRCLE

FIGURE 2.9 ■ Variations of oblique circles and methods used for sketching each.

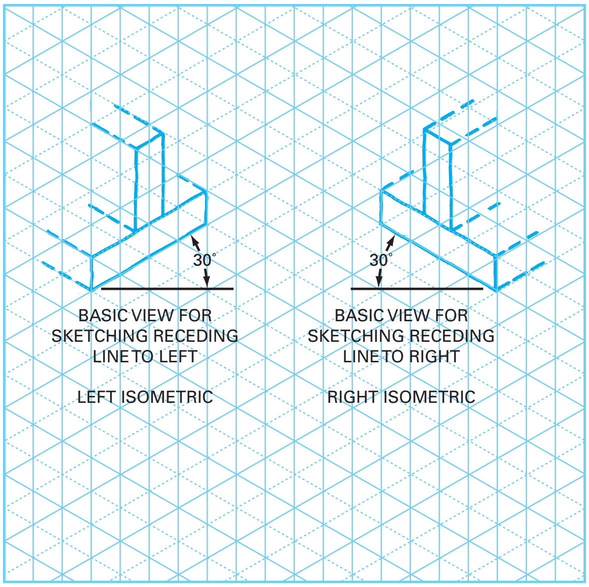

30°
30°
BASIC VIEW FOR SKETCHING RECEDING LINE TO LEFT
BASIC VIEW FOR SKETCHING RECEDING LINE TO RIGHT
LEFT ISOMETRIC
RIGHT ISOMETRIC

FIGURE 2.10 ■ Preliminary view for sketching isometric drawing of a fabricated T-support.

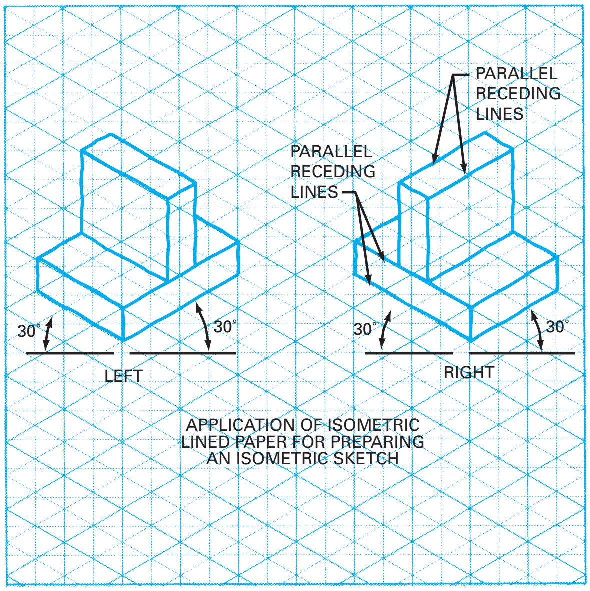

PARALLEL RECEDING LINES
PARALLEL RECEDING LINES
30°
30°
30°
30°
LEFT
RIGHT
APPLICATION OF ISOMETRIC LINED PAPER FOR PREPARING AN ISOMETRIC SKETCH

FIGURE 2.11 ■ Left and right isometric sketches of a fabricated T-support.

Isometric Sketching

To develop an isometric sketch, isometric graph paper is preferable. An isometric sketch has all of its surfaces shown at 30° angles. In the initial preparation of the sketch, a view of the object that best shows its shape and detail is selected and sketched at a 30° angle, Figure 2.10.

After completion of the basic view, Figure 2.10, parallel receding lines are sketched at 30° angles from each of the corners, Figure 2.11. Only those lines that represent the visible part of the object are shown. The sketch is completed by drawing the back edges at points that approximate the size of the object. Receding lines are reduced in length (foreshortened) to about two-thirds of the orthographic line length.

In cases where surfaces of the object are on different planes, a sequence is followed in developing the isometric sketch, starting from the front face and developing each portion progressively to the back face, in effect building upon the preceding portions, Figure 2.12.

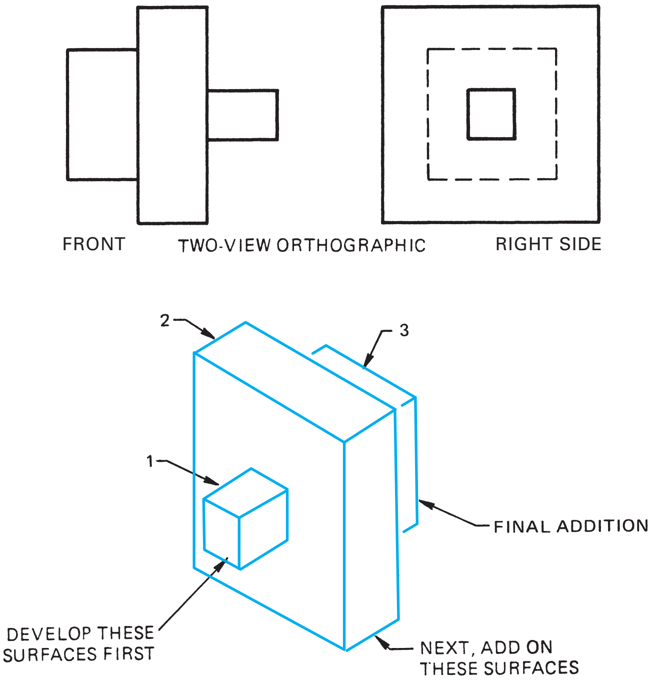


FIGURE 2.12 ■ Method used for developing an isometric sketch having surfaces on different planes.

For sketching isometric circles, the same basic techniques are applied as for sketching a regular circle. Variations of the isometric circle and how they are sketched are illustrated in Figure 2.13. For sketching isometric and oblique cyclinders, refer to Figure 2.14.

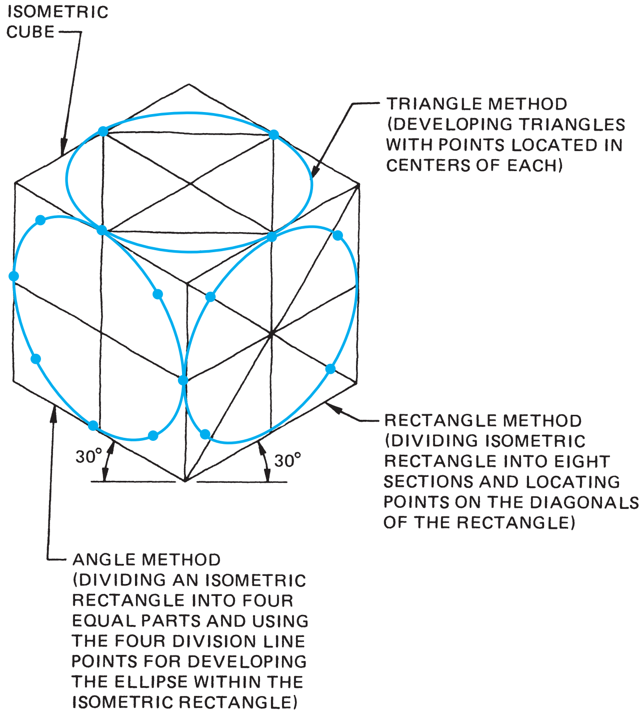

ISOMETRIC CUBE
TRIANGLE METHOD (DEVELOPING TRIANGLES WITH POINTS LOCATED IN CENTERS OF EACH)
RECTANGLE METHOD (DIVIDING ISOMETRIC RECTANGLE INTO EIGHT SECTIONS AND LOCATING POINTS ON THE DIAGONALS OF THE RECTANGLE)
30°
30°
ANGLE METHOD (DIVIDING AN ISOMETRIC RECTANGLE INTO FOUR EQUAL PARTS AND USING THE FOUR DIVISION LINE POINTS FOR DEVELOPING THE ELLIPSE WITHIN THE ISOMETRIC RECTANGLE)

FIGURE 2.13 ■ Variations of isometric circles.

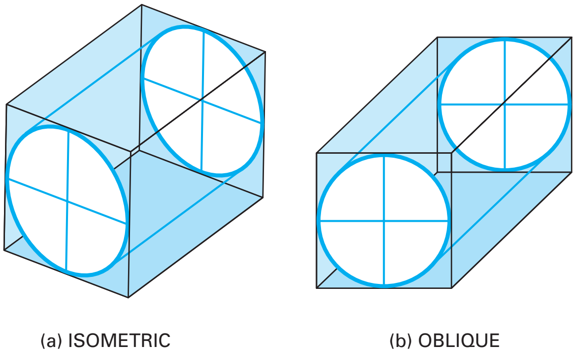


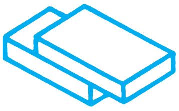
FIGURE 2.14 ■ Method for developing cylinders.

UNIT 2 REVIEW

Graph paper has been provided at the end of this review for your use.

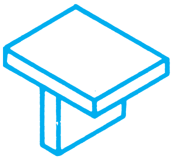
1. Identify the types of sketches illustrated below and sketch orthographic views as indicated for each.

a.



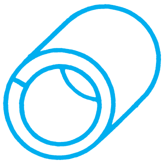
SKETCH RIGHT SIDE VIEW

b.



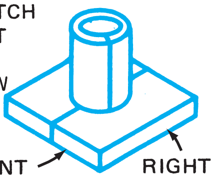
SKETCH TOP VIEW

c.

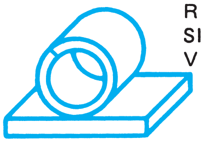


SKETCH BACK VIEW

d. SKETCH LEFT SIDE VIEW

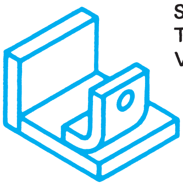


e.



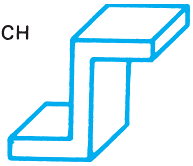
SKETCH RIGHT SIDE VIEW

f.

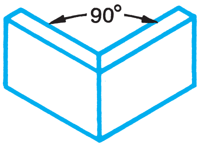


SKETCH TOP VIEW

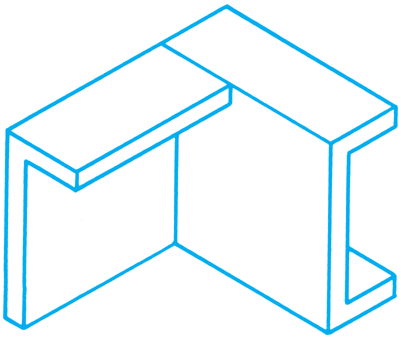
g. SKETCH LEFT SIDE VIEW



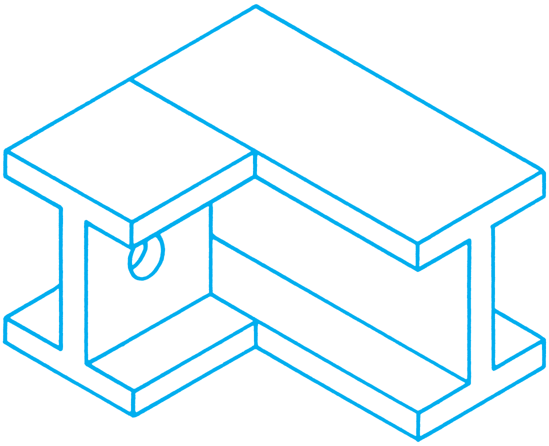
h. SKETCH TOP VIEW



i. SKETCH RIGHT SIDE, TOP, AND FRONT VIEWS (IDENTIFY EACH VIEW)



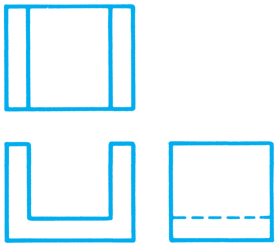
j. SKETCH TOP, FRONT, AND LEFT SIDE VIEWS (IDENTIFY EACH VIEW)



2. a. Prepare oblique sketches for the following orthographic drawings.
   b. Identify each of the views represented in each orthographic drawing.

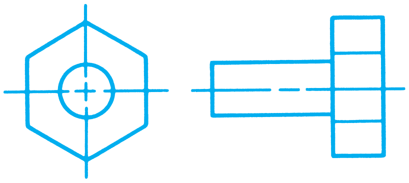
(1)

NOTE: SKETCH A
RIGHT OBLIQUE DRAWING



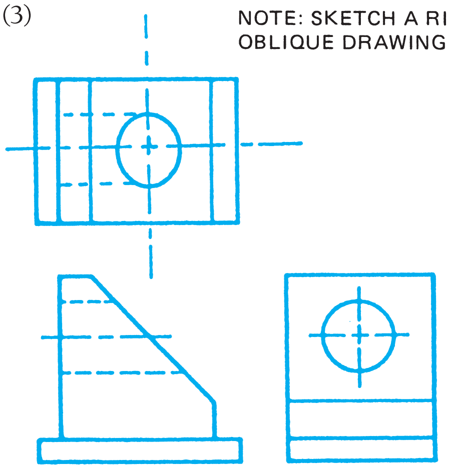
(2)

NOTE: SKETCH A
RIGHT OBLIQUE DRAWING



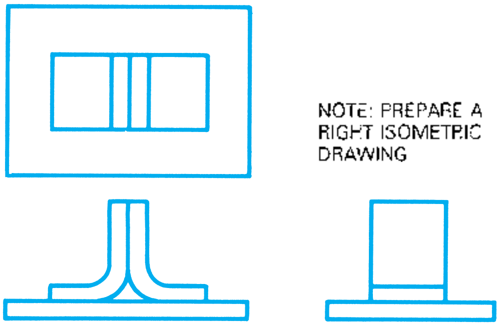
(3)

NOTE: SKETCH A RIGHT
OBLIQUE DRAWING



3. Prepare isometric sketches for each of the following orthographic drawings, right or left as specified.

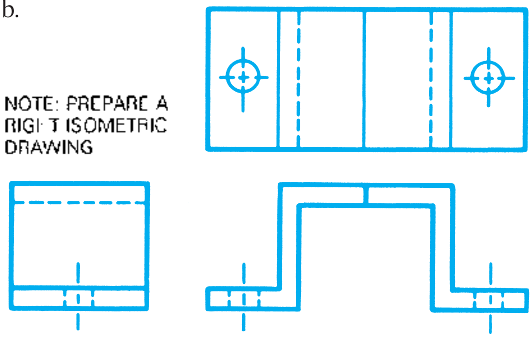
a.



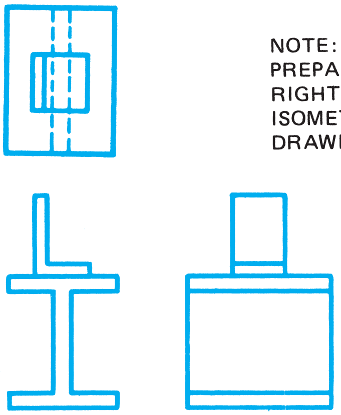
NOTE: PREPARE A
RIGHT ISOMETRIC
DRAWING

b.

NOTE: PREPARE A
RIGHT ISOMETRIC
DRAWING



c.



NOTE:
PREPARE A
RIGHT
ISOMETRIC
DRAWING

UNIT 3

Notes and Specifications

In many cases, it is not possible to give all the information needed on a print by the combined use of lines and dimensions. To provide additional information, notes and specifications are used.

A note is lettered information (in capital letters) concerning the details of construction. The note explains, specifies, or refers to the material and/or process needed to make the part. To conserve space on the print, and to save time in preparing the drawing, it is often shown as an abbreviation or symbol.

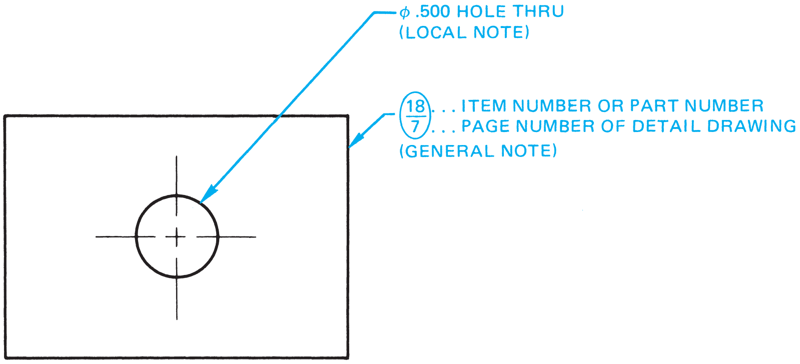

ϕ .500 HOLE THRU
(LOCAL NOTE)
18 . . . ITEM NUMBER OR PART NUMBER
7 . . . PAGE NUMBER OF DETAIL DRAWING
(GENERAL NOTE)

FIGURE 3.1 ■ Application of a local note.

When a note applies to a particular part on an object, it is called a local note. Such a note is placed near one of the views representing the part. A leader indicates the exact point of reference, **Figure 3.1**. A general note applies to the drawing as a whole and is placed in an open space away from the views so that it can be seen readily.

Examples of general notes are:

1. "Unless otherwise indicated, all fillet welds are ⅜″ size."
2. "Unless otherwise indicated, root openings for all groove welds are 3⁄16″."
3. "Unless otherwise indicated, all welds are to be made in accordance with specification A."

When a note specifies the material required, the welding process to be used, the type and size of electrode, and/or the kind and size of welding rod, it is called a specification. For example, in **Figure 3.2** the letter A refers to specification A.

In this case, specification A in the tail of the arrow indicates that No. 20, ¼″ bronze rod is to be used for the weld.

Specifications are often located near the views to which they refer. However, when many specifications are required, they are included on a separate sheet and referenced to the drawing.

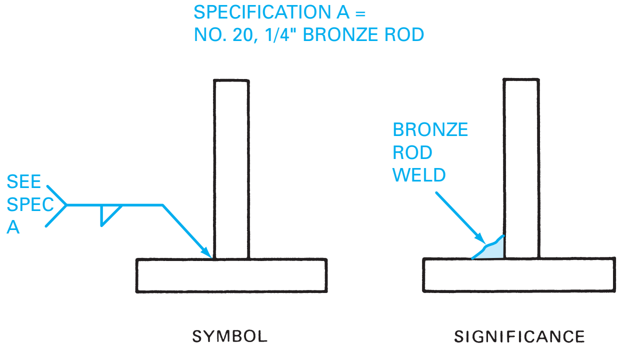


FIGURE 3.2 ■ Application of a specification.

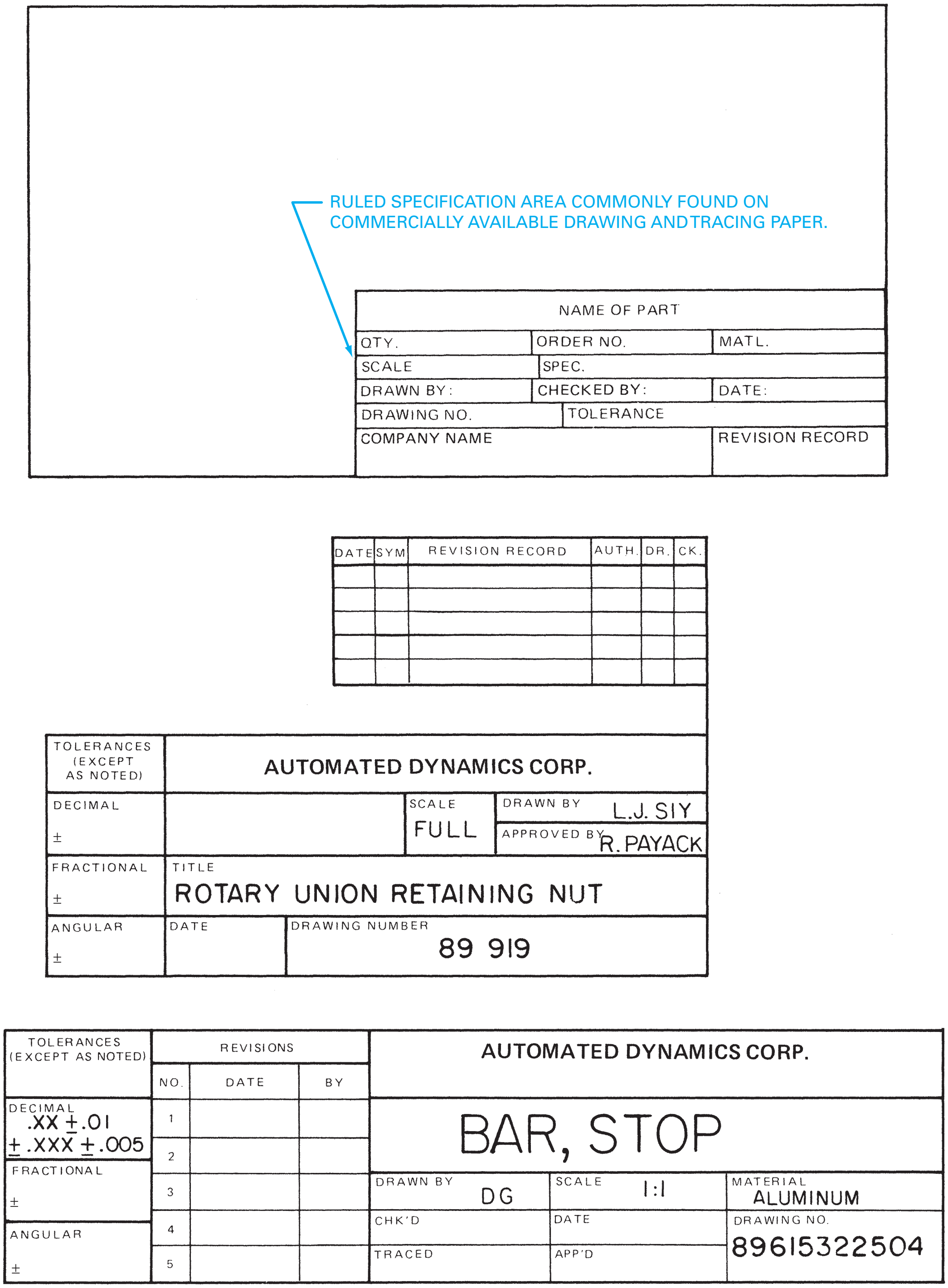
When a specification is general and applies to all or several views, it may be placed within a ruled space called a title block. It is usually denoted as such by prefacing the information with the word "specification." However, when specifying materials, the word "specification" is not necessarily used, but is implied. Typical title blocks are shown in Figure 3.3. The information that may be included in the title block consists of:

1. Name of part or project
2. Quantity required
3. Order number
4. Material
5. Scale size used
6. Specification (general)
7. Drawn by
8. Checked by
9. Drawing number
10. Date
11. Tolerances
12. Company name
13. Revision record

The standard sizes of commercial mechanical drawing sheets are identified by the letters A through E.

A = 8½″ × 11″
B = 11″ × 17″
C = 11″ × 22″
D = 22″ × 34″
E = 34″ × 44″

These letters may or may not be included as part of the drawing identification number.



RULED SPECIFICATION AREA COMMONLY FOUND ON COMMERCIALLY AVAILABLE DRAWING AND TRACING PAPER.

NAME OF PART
QTY. | ORDER NO. | MATL.
SCALE | SPEC.
DRAWN BY: | CHECKED BY: | DATE:
DRAWING NO. | TOLERANCE
COMPANY NAME | REVISION RECORD

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.

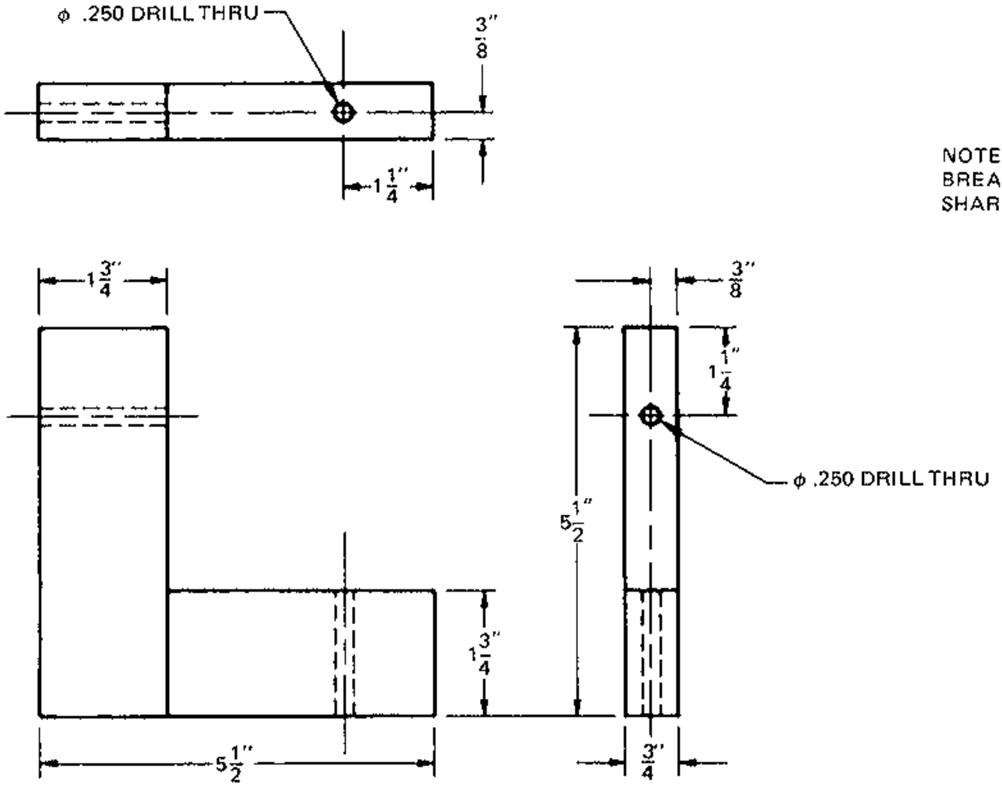
TOLERANCES (EXCEPT AS NOTED)
AUTOMATED DYNAMICS CORP.
DECIMAL ±
SCALE FULL
DRAWN BY L.J. SIY
APPROVED BY R. PAYACK
FRACTIONAL ±
TITLE ROTARY UNION RETAINING NUT
ANGULAR ±
DATE
DRAWING NUMBER 89 919

TOLERANCES (EXCEPT AS NOTED)
DECIMAL .XX ±.01 ± .XXX ±.005
FRACTIONAL ±
ANGULAR ±

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

AUTOMATED DYNAMICS CORP.
BAR, STOP
DRAWN BY DG | SCALE 1:1 | MATERIAL ALUMINUM
CHK'D | DATE | DRAWING NO. 89615322504
TRACED | APP'D

FIGURE 3.3 ■ Typical drawing master showing ruled title blocks.



NOTE:
BREAK ALL
SHARP EDGES

NOTE: ϕ IS USED TO DENOTE DIAMETER

CORNER BRACKET		
QTY. 6	ORDER NO. 63	MATL. MILD STEEL
SCALE: 3/8" = 1"	SPEC	
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 20	TOLERANCE FRACTIONAL ± 1/64 DECIMAL ± .003	
COMPANY NAME		

UNIT 3 REVIEW

Refer to the drawing, Corner Bracket, page 20.

1. What is the name of the part?

____

2. How many are required?

____

3. What is the order number?

____

4. What type of material is used?

____

5. How many views are shown?

____

6. Name each of the views shown.

____

____

____

____

7. Which view shows the shape of the object best?

____

8. In which views are leaders used?

____

9. Name each type of line used in the drawing.

____

____

____

____

____

10. What three types of lines are used to aid in dimensioning?

____

____

____

11. What item can be called a general note specification?

____

12. What item would be identified as a local note?

____

13. How many holes are to be drilled?

____

14. How deep is each hole to be drilled?

____

15. What is the diameter of the holes?

____

16. How many pieces are required to fabricate the part?

____

17. What do the hidden lines in each of the views represent?

____

18. What is the significance of the note, “Break All Sharp Edges”?

____

19. Identify an item within the title block that would be described as a specification.

____

4 UNIT

Dimensions

PURPOSE OF DIMENSIONS

Dimensions serve two important purposes:

1. They give the sizes needed to fabricate the part.
2. They indicate the locations where components of the part should be placed, assembled, machined, or welded.

Figure 4.1 illustrates the meaning of size and location dimensions. Note that linear dimensions used on a print may be shown in U.S. Customary and/or metric units. Information on metric dimensioning is included in Unit 23. Note that both units of measurement are used on dual-dimensioned drawings.

LINEAR AND ANGULAR DIMENSIONS

U.S. Customary linear dimensions may be given as whole numbers, fractions, and decimals. Preferred practice is to show dimensions in decimals, Figure 4.3. However, dimensions on drawings for weld fabrication operations are generally shown as fractional dimensions, while drawings for machining operations use decimal fractions. Drawings for both (weld) fabrication and machining use decimals or a mixture of both fractional and decimal dimensions for the appropriate type of operation. Also, current practice is to use a unidirectional dimensioning system, Figure 4.2, rather than the former practice of bidirectional or aligned dimensions, Figure 4.3.

The term common fraction refers to dimensions such as 1⁄64, 1⁄32, 1⁄16, ⅛, ¼, and ½ inch, Figure 4.2.

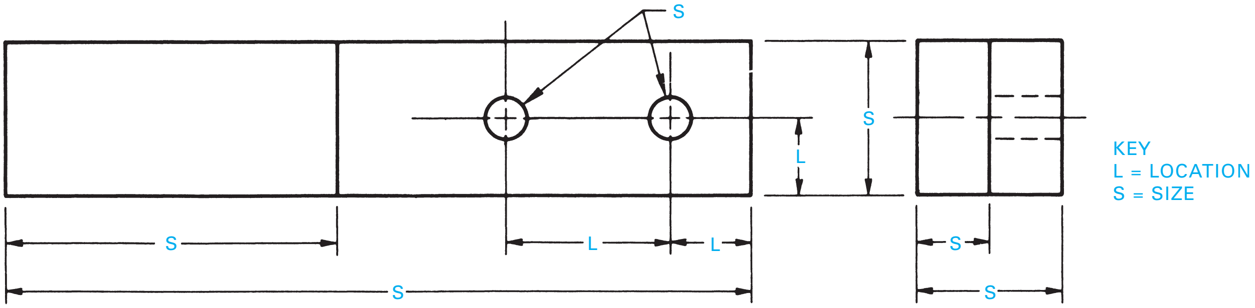
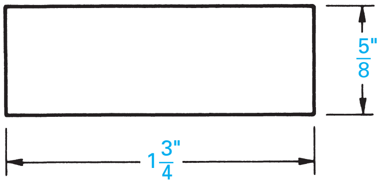
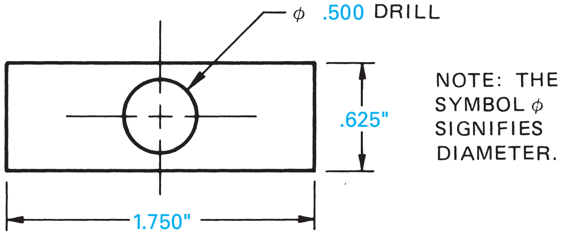


FIGURE 4.1 ■ Size and location dimensions.



(Preferred Method)

FIGURE 4.2 ■ Fractional dimensions. Unidirectional dimensions are read from the bottom of the drawing.



(Nonpreferred Method)

FIGURE 4.3 ■ Decimal dimensions. Bidirectional or aligned dimensions are read from the bottom and right side of the drawing.

Decimal fraction dimensions are used particularly when precision sizes are required. For example, when a drilled hole is dimensioned, a decimal dimension is used, Figure 4.3. The word "drill" may or may not follow the dimension. In cases where the hole is to be reamed, the word "ream" may be applied following the dimensions. If the hole is to be flame cut, the words "flame cut" may follow the dimension. The process specified for cutting the hole generally indicates the accuracy required. In instances where a process is not specified, the choice of method is made by the welder. However, consideration must be given to the accuracy required.

Angular dimensions are given when a line is at an angle to a horizontal, vertical, or another angular line. Examples of each are shown in Figure 4.4. The angle in each case is called the **included angle** and is shown in degrees, or in degrees and decimal parts of a degree. Although angular dimensions are sometimes shown in degrees and minutes (60°30′), the decimal fraction (60.5°) for minutes is preferred. Refer to Table 4.1.

Parts with bevels are commonly found on prints for welders. For joints to be welded, a bevel is a sloping edge that extends the full or partial length of the edge, Figure 4.5 and Figure 4.6. The sharp edge formed is commonly called a **feather edge.** The root face area along the edge is often called a **land.** Note that for welding purposes a chamfer is often identified and treated as a bevel.

There are several ways to dimension these features. One common method is by the use of a note with a leader. The amount of the bevel is given as a linear and a degree dimension, Figure 4.5 and Figure 4.6.

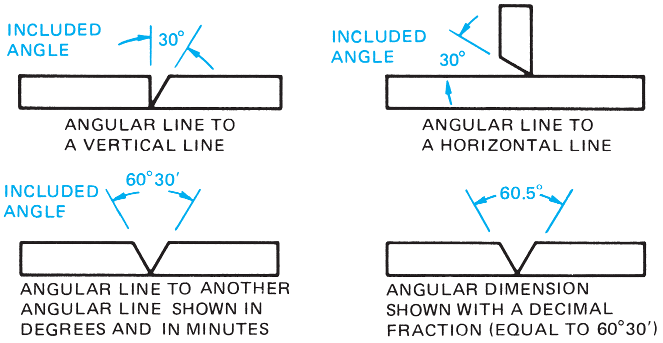

INCLUDED ANGLE
30°
ANGULAR LINE TO A VERTICAL LINE
INCLUDED ANGLE
30°
ANGULAR LINE TO A HORIZONTAL LINE
INCLUDED ANGLE
60°30′
ANGULAR LINE TO ANOTHER ANGULAR LINE SHOWN IN DEGREES AND IN MINUTES
60.5°
ANGULAR DIMENSION SHOWN WITH A DECIMAL FRACTION (EQUAL TO 60°30′)

FIGURE 4.4 ■ Dimensioning angles.

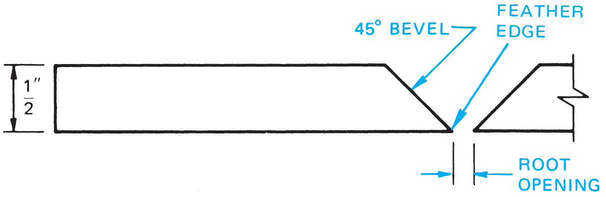


FIGURE 4.5 ■ Bevel dimension—full length.

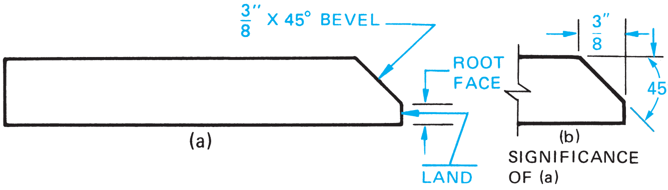


FIGURE 4.6 ■ Bevel dimension—partial length.

Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.	Min.	Deg.
1	.0166	11	.1833	21	.3500	31	.5166	41	.6833	51	.8500
2	.0333	12	.2000	22	.3666	32	.5333	42	.7000	52	.8666
3	.0500	13	.2166	23	.3833	33	.5500	43	.7166	53	.8833
4	.0666	14	.2333	24	.4000	34	.5666	44	.7333	54	.9000
5	.0833	15	.2500	25	.4166	35	.5833	45	.7500	55	.9166
6	.1000	16	.2666	26	.4333	36	.6000	46	.7666	56	.9333
7	.1166	17	.2833	27	.4500	37	.6166	47	.7833	57	.9500
8	.1333	18	.3000	28	.4666	38	.6333	48	.8000	58	.9666
9	.1500	19	.3166	29	.4833	39	.6500	49	.8166	59	.9833
10	.1666	20	.3333	30	.5000	40	.6666	50	.8333	60	1.0000

TABLE 4.1 ■ Minutes converted to decimals of a degree.

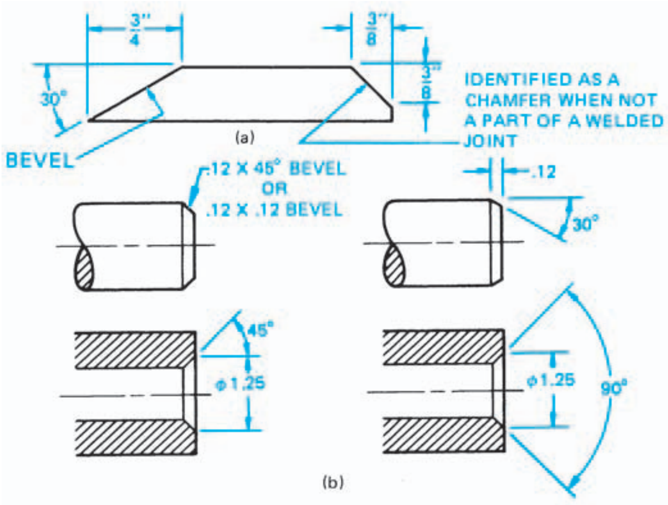

3"/4
3"/8
3"/8
30°
BEVEL
(a)
IDENTIFIED AS A CHAMFER WHEN NOT A PART OF A WELDED JOINT
.12 X 45° BEVEL OR .12 X .12 BEVEL
.12
30°
45°
ϕ1.25
ϕ1.25
90°
(b)

FIGURE 4.7 ■ Methods of dimensioning bevels.

Another method for dimensioning bevels is through the use of extension and dimension lines. The sizes may be given as two linear dimensions or as one linear and one angular dimension, Figure 4.7(a). When only a portion of the total edge is cut away at an angle for purposes other than welding, the edge is identified as a chamfer. Examples of bevels are shown in Figure 4.7(a) and Figure 4.7(b). Note that the symbol "×" included with the dimensions signifies places, times, or by. For example, 4× (times or places), and 4″ × 4″ (by).

RADIUS AND ARC DIMENSIONS

When the ends or corners of an object are to be rounded, a radius, arc, or curve is shown and is dimensioned by one of several methods, as shown in Figure 4.8. The methods of dimensioning include the use of an angular dimension and its radius (Figure 4.8a); two linear dimensions that indicate where the arc terminates, and its radius (Figure 4.8b); and a radius and centerlines that indicate the scope of the arc by inspection (Figure 4.8b). In the case of an arc with multiple radii, the dimensions shown are the location dimensions for the radii and the size of the radii, Figure 4.8(c). Note that the letter "R" is used to signify radius and is located preceding the dimension. In cases where a diameter dimension is applied, the symbol ∅ is used and precedes the dimension.

For dimensioning rounds, fillets, and roundouts the radius of the arc with a leader is usually sufficient, Figure 4.9(b).

Other variations in dimensioning radii and arcs are illustrated in Figure 4.9.

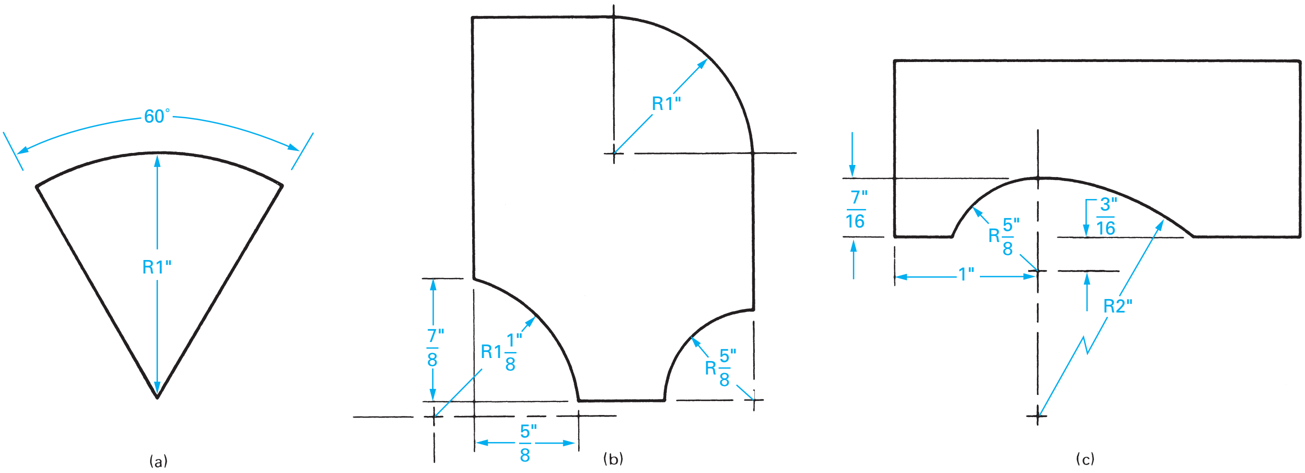
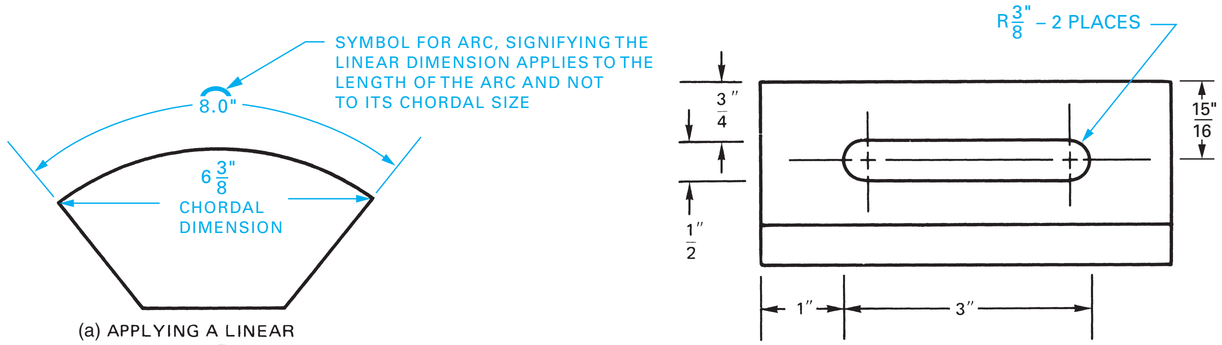
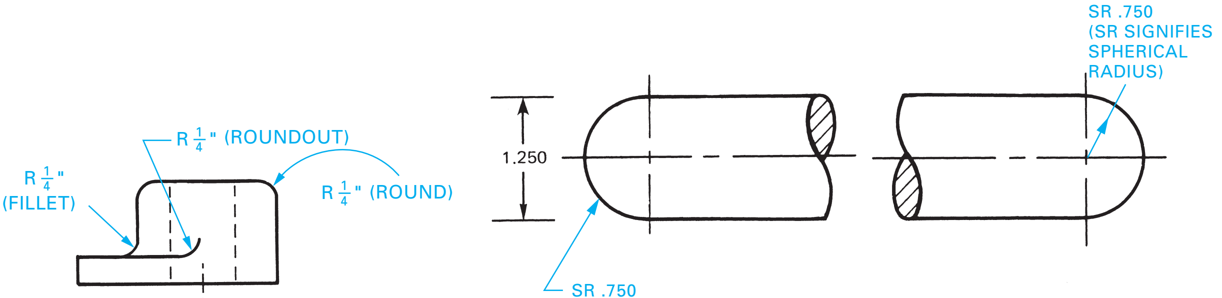


FIGURE 4.8 ■ Dimensioning arcs and radii.


SYMBOL FOR ARC, SIGNIFYING THE LINEAR DIMENSION APPLIES TO THE LENGTH OF THE ARC AND NOT TO ITS CHORDAL SIZE
8.0"
6 3/8"
CHORDAL DIMENSION
R 3/8" – 2 PLACES
3/4"
1/2"
15/16"
1"
3"

(a) APPLYING A LINEAR DIMENSION TO AN ARC

(c) DIMENSIONING A SLOT



(b) DIMENSIONING A ROUND, FILLET, AND ROUNDOUT

(d) DIMENSIONING A SPHERICAL RADIUS

FIGURE 4.9 ■ Variations in dimensioning arcs and radii.

DRILLED HOLE DIMENSIONS

Drilled hole dimensions are shown by the use of a leader and a note. These are usually applied to the view that shows the shape of the hole. The note gives the size of the drill, the number of holes to be drilled, and may also give the depth to which the holes are to be drilled. Holes with no depth dimension are to be drilled all the way through. However, this may also be indicated by adding the word "thru" to the drill size dimension.

Note that the hole depth may be indicated by the abbreviation DP for "deep" or the depth symbol ↧. A drill size can be given as a letter size, a number (wire gage) size, a fractional size, or a metric size. Figure 4.10 illustrates the various methods for dimensioning drilled holes.

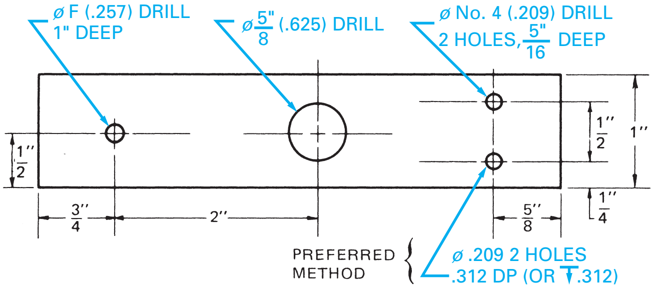


FIGURE 4.10 ■ Methods for dimensioning drilled holes.

COUNTERSUNK AND COUNTERBORED HOLES AND SPOTFACE DIMENSIONS

Several other types of round holes found on weldment fabrication drawings are counterbored, countersunk, spotfaced, and counterdrilled holes. The methods, abbreviations, and symbols used for dimensioning these holes are shown in Figure 4.11, Figure 4.12, Figure 4.13, Figure 4.14, and Figure 4.15.

Note that the abbreviation DP or the symbol ↧ for depth is applied to the dimensioning for a counterbored hole. The depth of a spotfaced hole is not given since the primary purpose of the hole is to provide a smooth seating surface. The depth of a countersunk hole is also not given. The major diameter of the countersink is provided.

FIGURE 4.11 ■ Representing counterbored, countersunk, spotfaced, and counterdrilled holes.

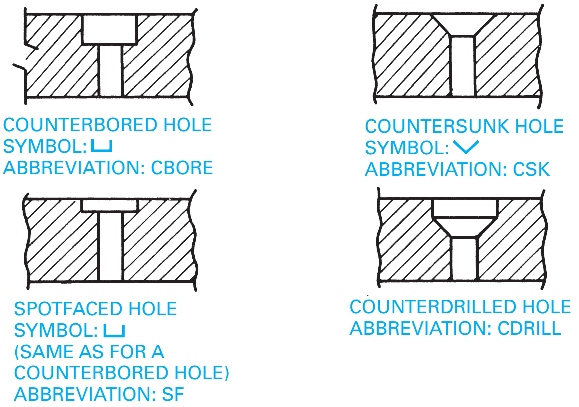


FIGURE 4.12 ■ Methods for dimensioning a counterbored hole.

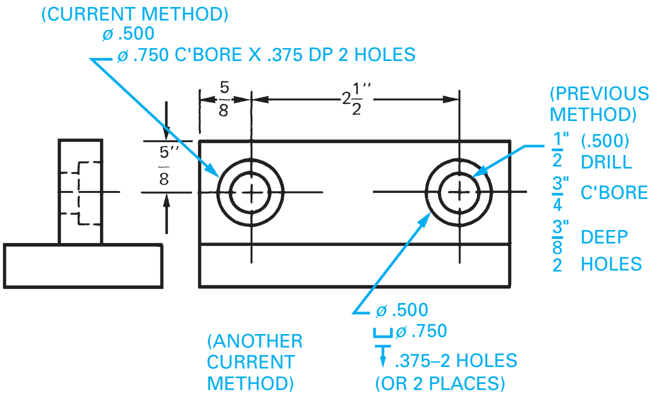
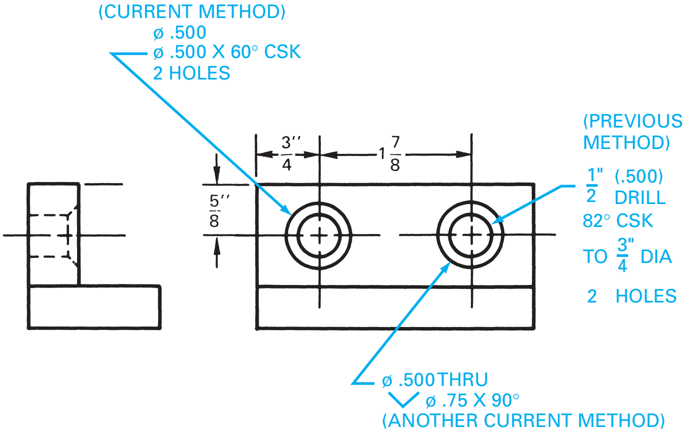


FIGURE 4.13 ■ Methods for dimensioning a countersunk hole.



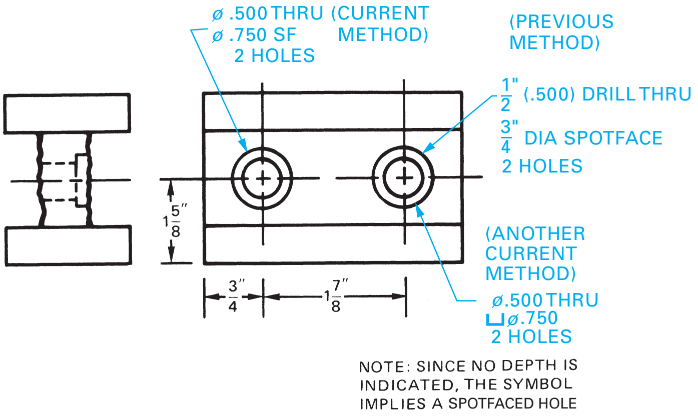


FIGURE 4.14 ■ Methods for dimensioning a spotfaced hole.

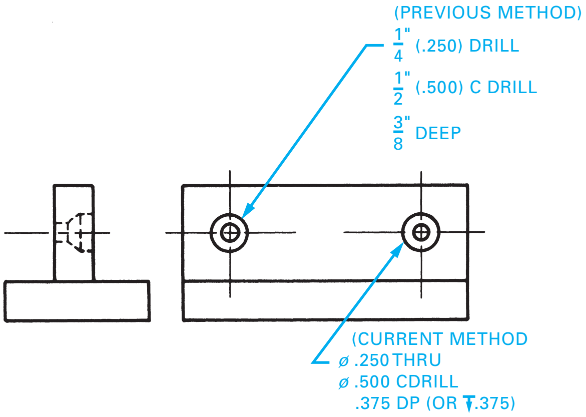


FIGURE 4.15 ■ Methods for dimensioning a counter drilled hole.

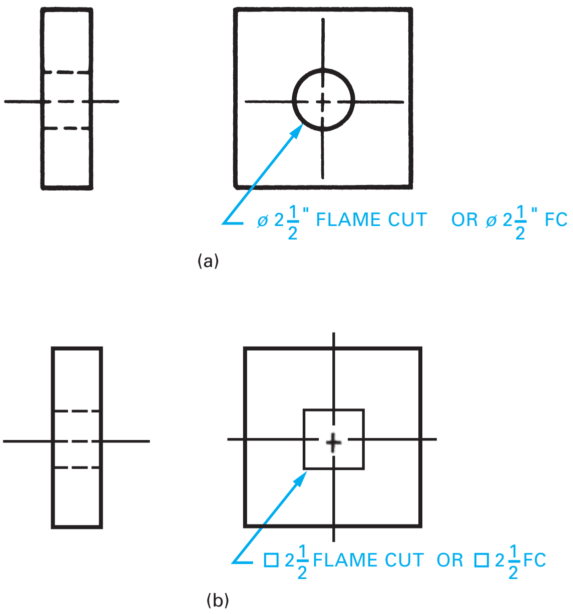

ø 2 1/2" FLAME CUT OR ø 2 1/2" FC
(a)
□ 2 1/2 FLAME CUT OR □ 2 1/2 FC
(b)

FIGURE 4.16 ■ Methods for dimensioning flame cut holes.

Another hole designation found on a weldment drawing is flame cut. When the hole is to be cut as a round shape, it is dimensioned like a drilled hole, except that the dimension is followed by the words “flame cut” or the abbreviation “FC,” Figure 4.16(a). Note that a flame cut hole is usually a large size (1 inch or larger) and is not as precise as a drilled hole. Therefore, its size is usually dimensioned using common fractions rather than decimals. Flame cutting of square holes may also be specified on a print. In such cases, the symbol for square □ may be used, Figure 4.16(b). Note that flame cut sizes are nominal (approximate).

TOLERANCE DIMENSIONS

Tolerance is another important element of dimensioning. It is a figure (or figures) given as a plus (+) or minus (−) quantity that allows for a variation in the dimension to which it is applied. It specifies the amount of error allowed when making a part. Any or all of the fractional, decimal, or angular dimensions found on a print can be given tolerances. When a tolerance is given, it follows the dimension to which it refers, or it is given as a note or specification. For example:

FOLLOWING DIMENSION:

12″ ± ⅛″ 12.740″ ± .005″ 60° ± 2°

NOTE: UNLESS OTHERWISE SPECIFIED TOLERANCES ARE AS FOLLOWS:

FRACTIONAL DIMENSIONS	± ⅛″
DECIMAL DIMENSIONS	± .005″
ANGULAR DIMENSIONS	± 2°

Tolerances are used to ensure the accuracy and proper fit of parts. This allows assembly and construction with a minimum of rework or adjustment. For example, it is almost impossible to cut a bar of material to an exact length with a manually operated torch. Therefore, a plus and minus tolerance is allowed. If a bar is to be cut 12″ long with a ±⅛ tolerance, the largest allowable size is 12⅛″ and the smallest is 11⅞″.

For many parts, the tolerances are standardized and are found in prepared tolerance tables. If no tolerance is given on a print, it can be assumed that extremely accurate sizes are not required. If such is the case, it is standard practice to use a ± tolerance of 1⁄64 for common fraction dimensions, a ± .010″ tolerance for decimal fraction dimensions shown to two decimal places (.75″, 1.25″), and a ± .005″ tolerance for decimal fraction dimensions shown to three decimal places (.750″, 1.375″).

Tolerances may also be expressed or implied by other than + or − values. For example, limit dimensions may be used to specify allowable sizes as follows:

R.362 MIN. — Signifies the minimum radius (R) should not be less than .362
R.375 MAX. — Signifies the maximum radius (R) should not exceed .375, may be expressed as .362 − .375
$\frac{.362}{.375}$ — Signifies the range in size that must be within .362 and .375, or a tolerance range of .013 (.375 − .362 = .013)

SCALE SIZES

Dimensions placed on a print my be full, enlarged, or on a reduced scale. A reduced scale size is more commonly used on prints and may be one of the following. The scale size that is used is noted on the print.

¾″ = 1″ ½″ = 1″ ¼″ = 1″ ⅛″ = 1″

However, an enlarged scale size is often used for detail drawings describing small components, for example, ½″ = ⅛″.

The scale size of a drawing is always in direct proportion to the actual size of the object. The scale is always listed in the form of an equation, although it is actually a ratio. The figure on the left side of the equal sign represents the quantity of measure for the drawing. The figure on the right represents the corresponding quantity of measure for the object being illustrated. For example, assume that a scale of ½″ = 1″ is used and the dimension of the object is 6″ long. The linear distance on the print, therefore, is half of the object distance, or 3″.

THREAD DIMENSIONS

Weldments very often include threaded parts. Standard thread symbols are used on prints to represent threaded parts. Figure 4.17 shows how external threads are represented. Internal threads (tapped holes) are represented by the symbols shown in Figure 4.18.

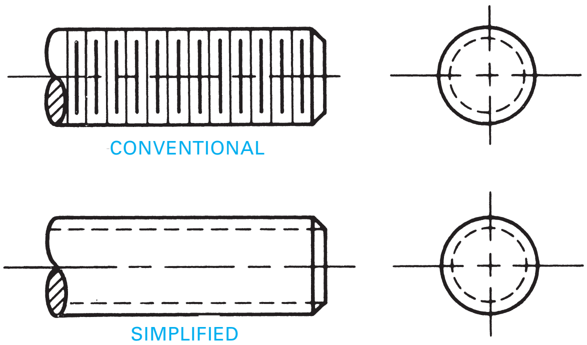


FIGURE 4.17 ■ External thread symbols.

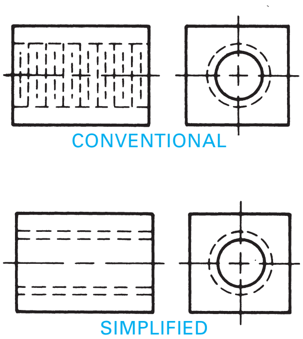


FIGURE 4.18 ■ Internal thread symbols.

An internal thread can be shown in a section view (cutaway view) by either of the symbols given in Figure 4.19.

Both internal and external threads are dimensioned using a leader followed by the thread specification, Figure 4.20. Note that the elements of the thread specification are also defined in the figure. When the thread is a left-handed thread, LH is added following the class of fit specification. In all other cases, the thread is considered to be a right-handed thread. Formerly, the common V-thread forms were identified as National Coarse (NC) or National Fine (NF). With the inclusion of these thread forms in the metric system, they are more often identified as Unified National Coarse (UNC) and Unified National Fine (UNF).

When a thread class of fit is specified, it is shown in a sequence as illustrated in Figure 4.20. There are three classes of fit that are commonly used. Class I for a loose fit, Class II for a standard fit (as is used for commercially available bolts and nuts), and Class III for a more precise and tighter fit.

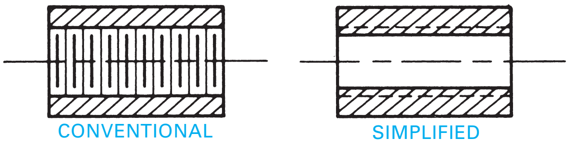
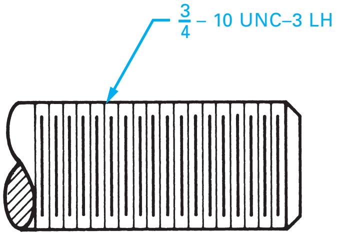


FIGURE 4.19 ■ Internal thread symbols for sections.



$\frac{3}{4}$ = DIAMETER OF THE THREAD

10 = NUMBER OF THREADS PER INCH

UNC = FORM OF THE THREAD (UNIFIED NATIONAL COARSE) (MAY ALSO BE CLASSIFIED AS UNF–UNIFIED NATIONAL FINE)

3 = CLASS OF FIT

LH = DIRECTION OF THREAD (LEFT HAND)

FIGURE 4.20 ■ Elements of a thread specification.

DIMENSIONING METHODS

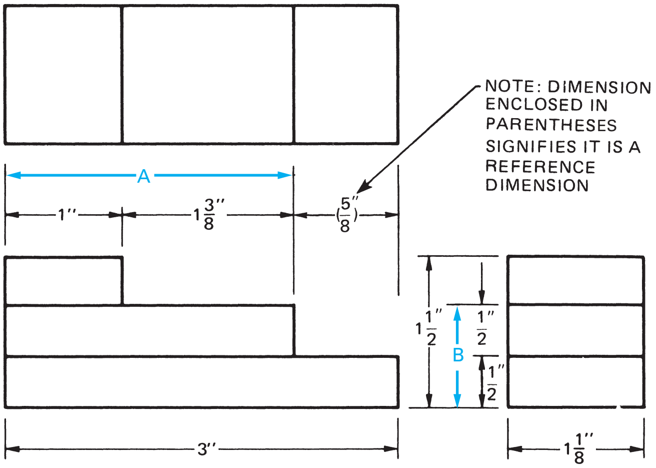
There are two basic methods for dimensioning a part: **conventional dimensioning** and **baseline dimensioning.**

The conventional method of dimensioning is illustrated by Figure 4.21. In this method, the overall dimensions of length, width, and height are given. Dimensions A and B are not given because they are easily found by adding the given dimensions. If dimensions A and/or B were given, they would be identified as reference dimensions. A reference dimension is obtained by adding and/or subtracting other dimensions found on the drawing. A reference dimension is used to expedite reading the drawing; however, it is not a necessary dimension. If a part is dimensioned so that the overall sizes are not given, those dimensions that make up the total must be added to find the overall sizes. Fractional or decimal dimensions may be used, but decimal dimensioning is preferred.

Baseline dimensioning, Figure 4.22, differs from conventional dimensioning in that all dimensions originate from baselines. When baseline dimensioning is used, the dimensions normally are expressed as three-place decimals.

Baselines are object lines that usually represent machined surfaces, as indicated by the symbol V. Baselines may also originate from centerlines.

The advantage of baseline dimensioning is that calculations are not required to find a dimension. It is a method commonly used to dimension precision parts. This method does not give rise to the cumulative error that occurs with conventional dimensioning.



NOTE: DIMENSION ENCLOSED IN PARENTHESES SIGNIFIES IT IS A REFERENCE DIMENSION

FIGURE 4.21 ■ Conventional dimensioning (A, B are possible reference dimensions).

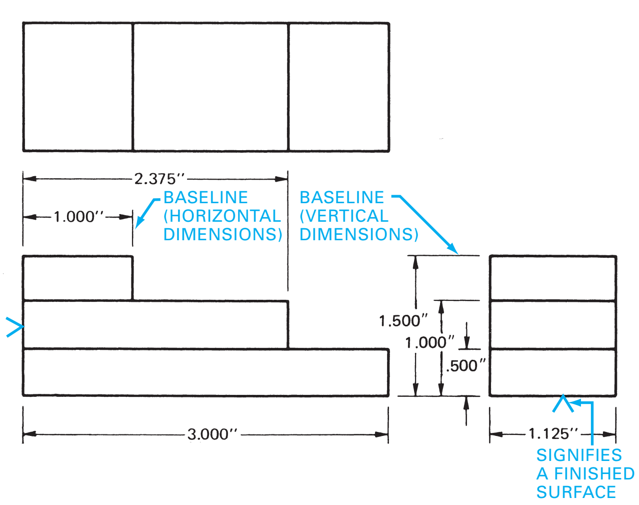

2.375″
1.000″
BASELINE (HORIZONTAL DIMENSIONS)
BASELINE (VERTICAL DIMENSIONS)
1.500″
1.000″
.500″
3.000″
1.125″
SIGNIFIES A FINISHED SURFACE

FIGURE 4.22 ■ Baseline dimensioning.

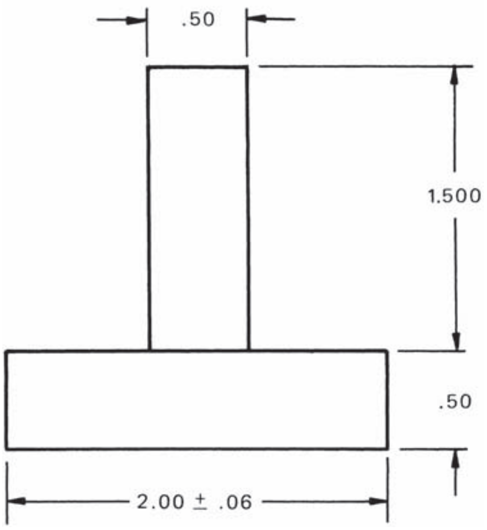


FIGURE 4.23 ■ Reference to a basic size dimension.

OTHER TERMS COMMONLY USED IN DIMENSIONING

Basic size refers to the base size of a part to which a tolerance value is applied. For example, in Figure 4.23, the basic size dimension is 2.00 with a tolerance of ± .06.

Actual size refers to the size of the part when measured.

Nominal size refers to a dimension that represents an approximate size. It is used for general identification of a size, such as for identifying pipe, pipe fittings, and lumber. Limits of size refers to dimensions that indicate the upper (maximum) limit and the lower (minimum) limit to which the size of a part can be made. Limits may be shown in several ways. Examples follow:

2.50	upper limit
2.37	lower limit

(lower limit) 2.37 – 2.50 (upper limit)

- *Call out* refers to identification of each of the parts on an assembly drawing by means of numbers assigned to the parts.
- The numbers are referenced to a bill of materials to obtain the information needed to produce each part.

DUAL DIMENSIONING

Dual dimensioning refers to the application of both U.S. Customary and metric units (usually in millimeters) of measurement on a drawing, Figure 4.24. It is used on drawings to permit the manufacture of parts in either unit of measurement, depending upon their application and/or where they will be marketed.

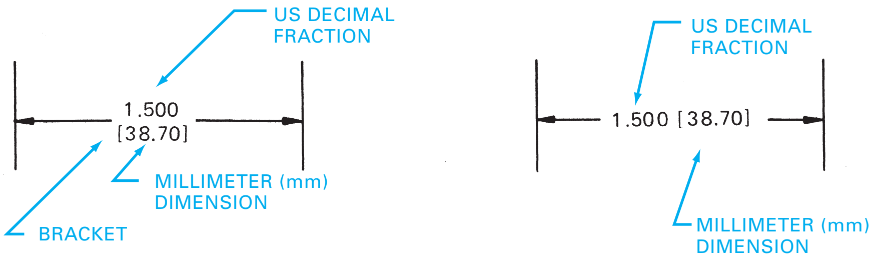


FIGURE 4.24 ■ Examples of dual dimensioning using the bracket method.

UNIT 4: REVIEW A

Graph paper has been provided at the end of this review for your use.

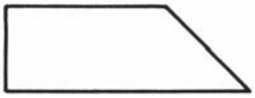
1. Give two functions of dimensions.

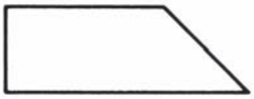
2. List two ways a dimension can be expressed in U.S. Customary units.

3. How is a precision dimension usually expressed?

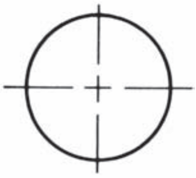
4. a. Show by a simple sketch the difference between a bevel and a chamfer.
   b. For welding purposes, is a distinction made between a chamfer and a bevel?
   c. Which term is commonly used for both?

5. Show two ways in which the given illustrations might be dimensioned. Apply the dimensions to the illustrations.

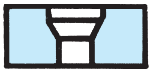


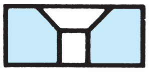


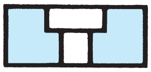
6. Indicate three items of information that might be found in the dimensioning of a drilled hole using a leader.

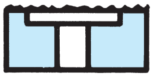


7. Identify the type of hole represented by each sketch. Add the dimensions that must be applied to each.









8. What is the meaning of *tolerance* as applied to dimensions?

9. Sketch three methods of dimensioning a radius or arc on a print.

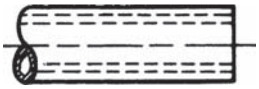
10. What are the maximum and minimum sizes for the dimensions shown in the table?

	Dimension	Tolerance	Maximum	Minimum
a.	8″	±1/16″		
b.	7 1/32″	±3/64″		
c.	6′ 11 7/8″	±3/16″		
d.	8.902″	±.003″		
e.	1.002″	±.005″		
f.	82°	±5′		
g.	105°	±2°		

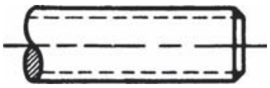
11. What is the linear length shown on a print for the dimensions given, when drawn to the scale size specified?

	Dimension	Scale	Size
a.	8″	1/4″ = 1″	
b.	18′ 6″	1/8″ = 1′	
c.	2 1/16″	2″ = 1″	
d.	2 3/64″	3″ = 1″	

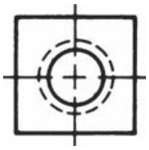
12. Which of the thread symbols below represent internal threads and which represent external threads?



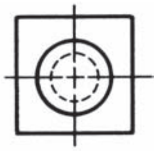
a.



b.



c.



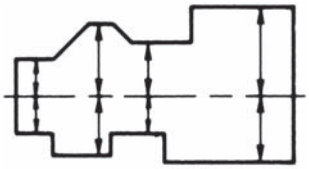
d.

13. List the information that is signified by the following thread specification:

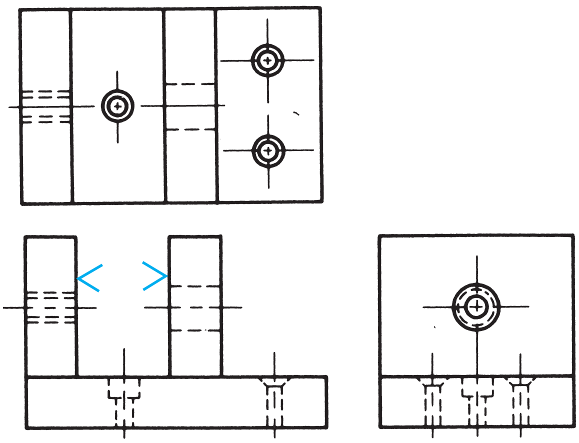
¾–10 UNC–LH

14. Explain the difference between the conventional method of dimensioning and the baseline method of dimensioning.

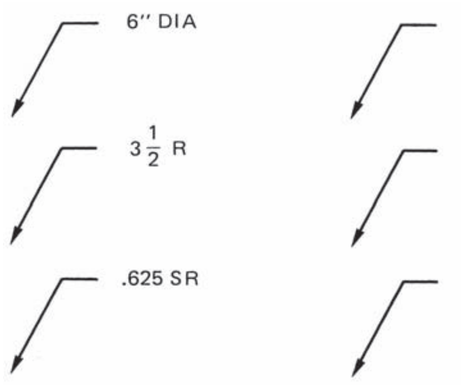
15. What kind of dimensioning is illustrated in the sketch below?



16. a. Apply appropriate dimensions to the different types of holes shown in the part below. Assume any necessary sizes.
    b. Apply the dimension lines required for locating the holes.
    c. Identify the types of holes found in the part.
    d. Explain the significance of the ∨ symbol shown on the front view.



17. Apply the preferred practice of dimensioning to the leaders shown on the right.



18. Explain what is meant by the term "call out."

19. Refer to the "Roller Support" drawing on page 34 and call out the appropriate items shown on the drawing.

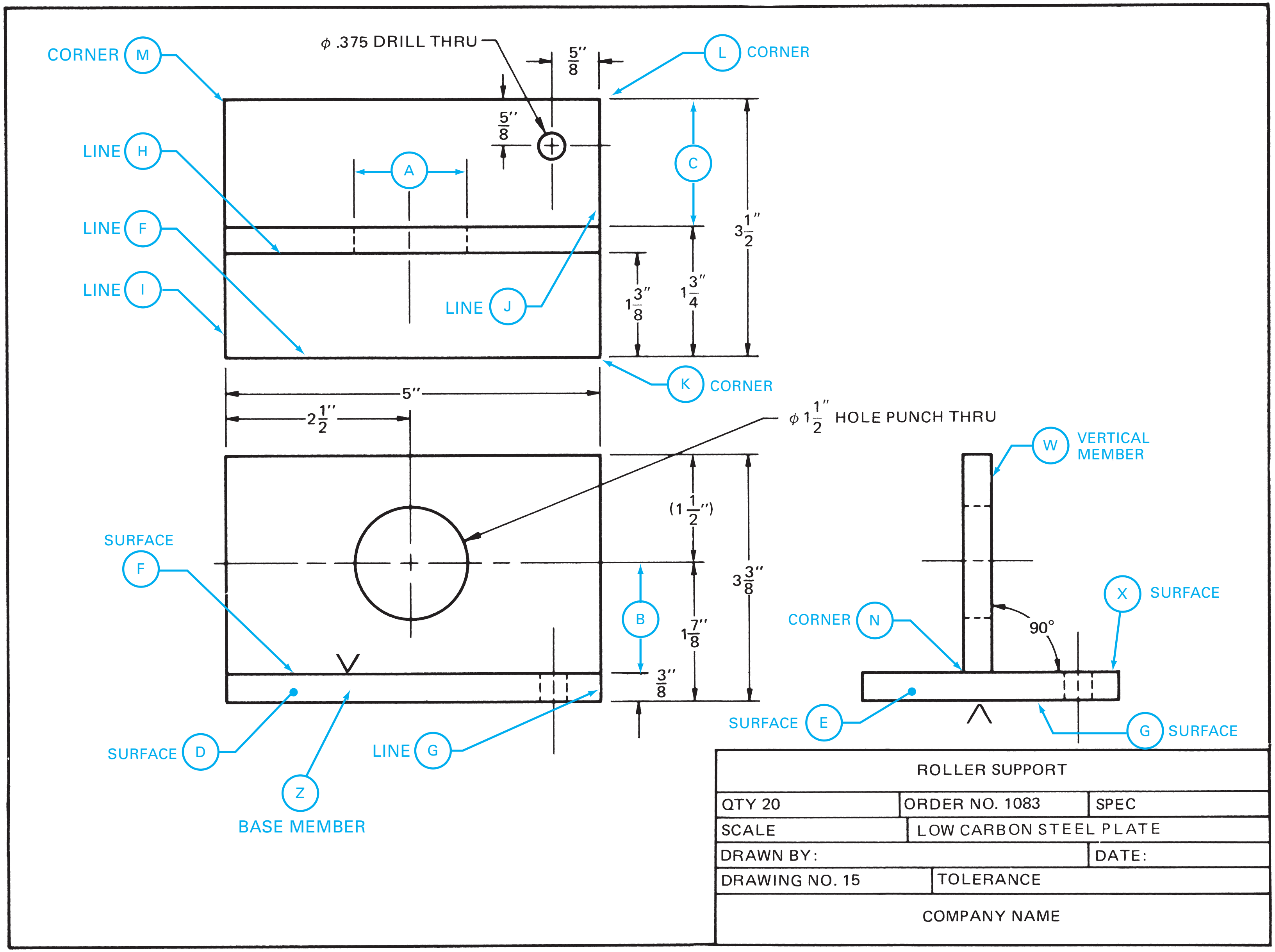
20. Explain the difference between the terms "actual size" and "nominal size."

21. Explain the significance of the following dimensions:

a. ←1.75→ b. ←8.37–8.50→
1.65

a.
b.

22. With reference to dimensioning, explain the difference between the terms "clearance" and "allowance."



ROLLER SUPPORT		
QTY 20	ORDER NO. 1083	SPEC
SCALE	LOW CARBON STEEL PLATE	
DRAWN BY:		DATE:
DRAWING NO. 15	TOLERANCE	
COMPANY NAME		

UNIT 4: REVIEW B

Refer to the drawing, Roller Support, page 34.

1. What is the name of the object?

____

2. How many are required?

____

3. What type of material is used?

____

4. What is the overall length of the object?

____

5. Name the views shown.

____

____

6. In which view is the width dimensioned?

____

7. In which view is an angular dimension used?

____

8. How many hidden lines are shown?

____

9. What is the size of distance Ⓐ?

____

10. What is the size of distance Ⓑ?

____

11. What is the size of distance Ⓒ?

____

12. How many holes are there in the completed order?

____

13. How are the holes to be made?

____

14. How is the largest hole made?

____

15. Where is a decimal fraction dimension found on the drawing?

____

16. Which line represents surface Ⓔ in the front view?

____

17. Which line represents line Ⓖ in the top view?

____

18. How thick is the upright plate?

____

19. Which line represents surface Ⓓ in the top view?

____

20. Which line represents corner Ⓝ in the top view?

____

21. a. Identify the surface or surfaces to be finished.

____

b. Sketch the symbol used.

22. Which dimension would be identified as a reference dimension?

____

23. Give the location dimensions for the large hole.

____

24. What is the specified tolerance for the angular dimension?

____

25. Identify the hole that can be a nominal size.

____

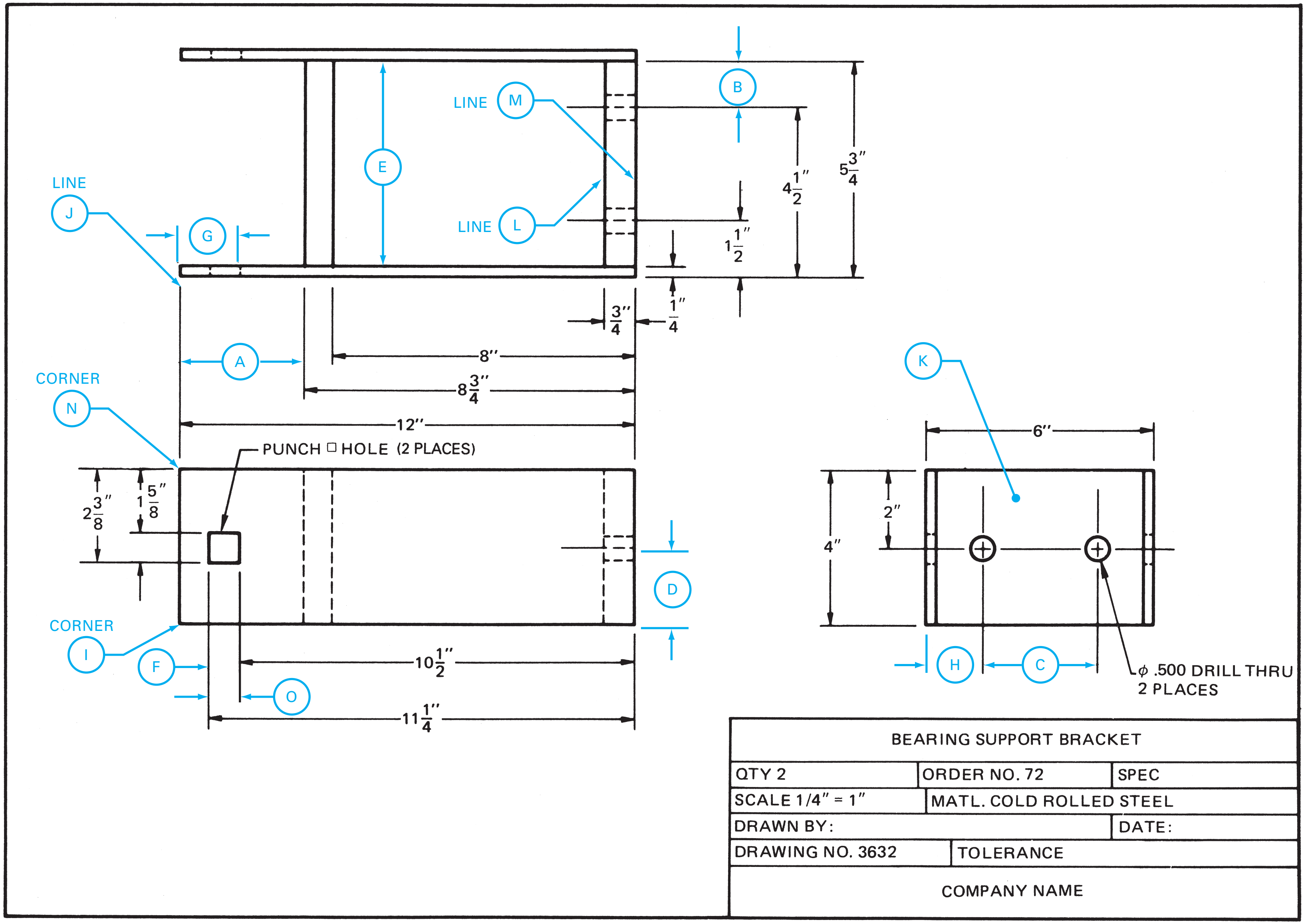
26. What is the common fractional size of the hole to be drilled?

____

27. List the location demensions for:

a. Drilled hole______________________________

b. Punched hole______________________________



BEARING SUPPORT BRACKET		
QTY 2	ORDER NO. 72	SPEC
SCALE 1/4" = 1"	MATL. COLD ROLLED STEEL	
DRAWN BY:		DATE:
DRAWING NO. 3632	TOLERANCE	
COMPANY NAME		

SUMMARY REVIEW NO. 1

Graph paper is provided at the end of this review for your use.

Refer to the drawing, Bearing Support Bracket, page 36.

1. What scale size is used?

____

2. With reference to the above scale, what linear length on the drawing represents a dimension of 8″?

____

3. List any notes found on the print.

____

4. List an item classified as a specification.

____

5. What are the location dimensions for the drilled holes?

____

6. List the location dimensions for the square holes.

____

7. a. What are the dimensions for the following distances?

Ⓐ ______________ Ⓔ ______________

Ⓑ ______________ Ⓕ ______________

Ⓒ ______________ Ⓖ ______________

Ⓓ ______________ Ⓗ ______________

b. If dimension Ⓐ had been included on the drawing, identify the kind of dimension it would be classified as.

____

8. What line in the top view is represented by surface Ⓚ?

____

9. What corner(s) in the front view are represented by line Ⓙ?

____

10. What method of dimensioning is shown to the right of the top view?

____

11. List the types of lines found on the print.

____

____

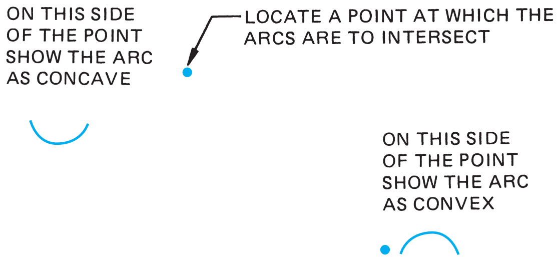
____

____

____

12. Convert the common fraction dimensions to decimal fraction dimensions and apply them to the drawing next to the common fraction dimensions.

13. Prepare a sketch that illustrates two intersecting arcs with equal radii. Use one of the techniques previously described in the text. Show all guidelines and points for developing each arc.

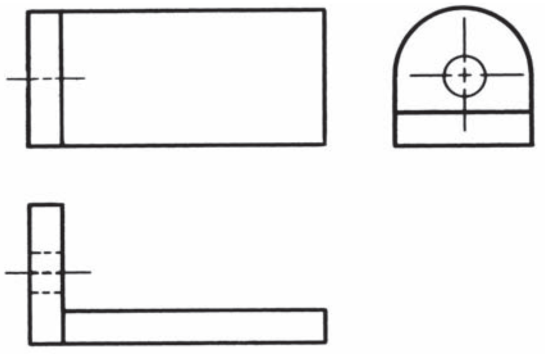

ON THIS SIDE OF THE POINT SHOW THE ARC AS CONCAVE
LOCATE A POINT AT WHICH THE ARCS ARE TO INTERSECT
ON THIS SIDE OF THE POINT SHOW THE ARC AS CONVEX

14. a. Prepare a right oblique sketch of the following three-view orthographic drawings.

b. Which of the orthographic views is incomplete?

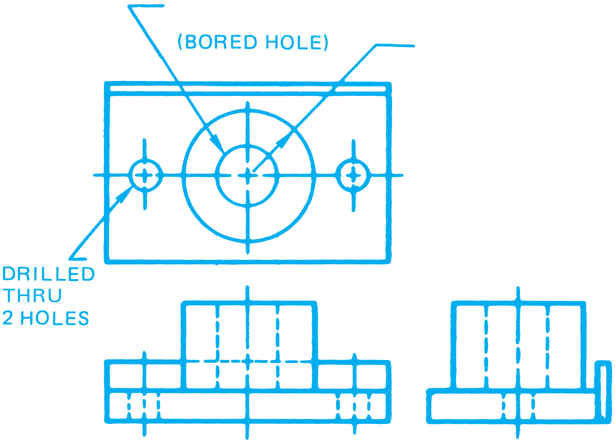
____

c. Correct the view that is incomplete.



15. a. Prepare a right isometric sketch of the following three-view orthographic drawing.

    b. Identify the orthographic views represented.



    c. Show the location and size dimensions that would be applied to the drilled holes. Use hypothetical dimensions for this purpose and apply them to the appropriate orthographic view.

    d. How many separate pieces are required to fabricate the unit as shown?

    e. Complete the leader on the drawing to show how the radius of the largest circumference would be dimensioned. Use a 3″ radius dimension.

    f. On the drawing, add the dimension for the bored hole (1¼″ dimension).

    g. Add the basic size that could be applied to each of the views. Use approximate sizes.

16. What is dimension Ⓞ?

17. What fractional size is the drilled hole?

18. List the location dimensions for:

    a. Drilled holes

    b. ☐ holes

5 UNIT

Bill of Materials

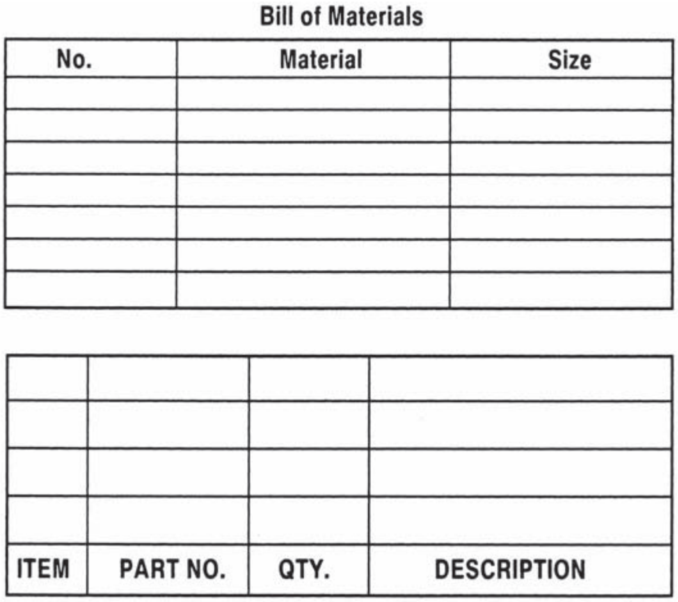
PREPARATION OF A BILL OF MATERIALS

The designer/drafter is usually required to prepare a list or bill of materials along with weldment drawings. This list enables some other person, such as a stockroom attendant, a welder's helper, or the operator of flame-cutting equipment, to cut or otherwise prepare the various stock pieces needed to fabricate the object.

In many cases, the bill of materials is simply a list of dimensions and the number of pieces required. For complex or irregularly shaped objects, sketches may be added to fully describe certain parts.

To prepare the bill of materials, each part must be considered individually. All pertinent information, such as part name or number, number of pieces required, thickness, width, length, and kind of material, should be listed for each part.

A bill of materials is shown directly on detail and subassembly drawings within a ruled block, or on a separate sheet attached to the drawing. Figure 5.1 illustrates two examples of ruled blocks found on drawings for inclusion of bill of materials information. Note that a ruled block for this purpose is in addition to the title block, which provides other kinds of information.



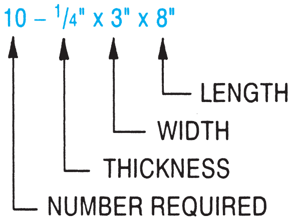
Bill of Materials

No.	Material	Size

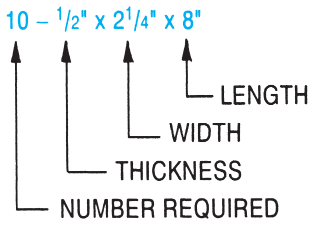
ITEM	PART NO.	QTY.	DESCRIPTION

FIGURE 5.1 ■ Examples of ruled blocks for bill of materials.

The sizes of a part for a bill of materials are expressed in a particular order as illustrated by the following example. Assume that a T-joint is to be fabricated from two plates. Consider one plate at a time and list the number required and the thickness, width, and length of each. Figure 5.2 shows that 10 pieces are required. The bottom part Ⓐ is ¼″ thick, 3″ wide, and 8″ long. This information is written as:



Ten pieces of the upright part Ⓑ are also required. This part is ½″ thick, 2¼″ wide, and 8″ long and is specified as:



The basic bill of materials for the T-joint is:

PART Ⓐ 10 – 1/4" x 3" x 8"

PART Ⓑ 10 – 1/2" x 2 1/4" x 8"

Additional information can be included in the bill of materials to reduce the likelihood of any misunderstanding. For example, the list of materials for Figure 5.2 gives no indication as to whether the parts are to be cut from sheet, plate, or flat bar. **Sheet metal** is defined as metal 3⁄16″ or less in thickness and more than 6″ in width. **Metal plate** is greater than 3⁄16″ in thickness, and also is more than 6″ in width. Both plate and sheet are available in widths up to 200 inches and lengths of up to 100 feet. **Flat bar** stock differs from plate and sheet in that the width of the bar does not exceed 6″. Many thicknesses are available, and the length may vary from 18 to 22 feet. Note that the kind of material to be used (i.e., SAE 1020 steel, aluminum, copper, etc.) will also need to be specified when of a special nature.

Since Figure 5.2 does not indicate the stock to be used, it can be assumed that it makes little difference from which stock form the parts are cut. However, if the parts required are to be cut from plate, Figure 5.3, the bill of materials is written as:

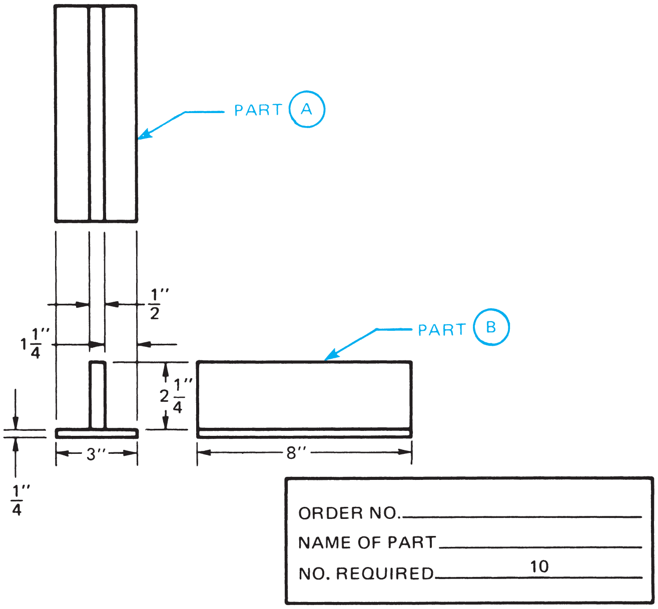
10 – 1/4" PLATE 3" x 8"

10 – 1/2" PLATE 2 1/4" x 8"

OR

10 – 1/4" P_L 3" x 8"

10 – 1/2" P_L 2 1/4" x 8"



ORDER NO.
NAME OF PART
NO. REQUIRED 10

FIGURE 5.2 ■ T-joint.

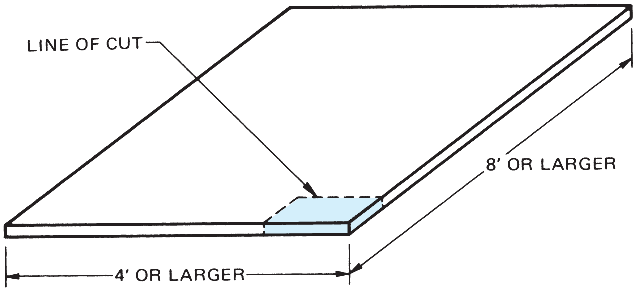
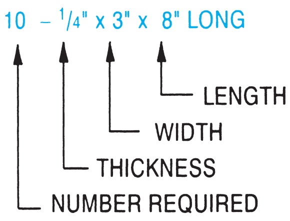
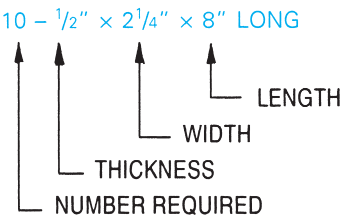


FIGURE 5.3 ■ Cutting material from plate.

If the parts required are to be cut from flat bar, Figure 5.4, the material requirement is written as:





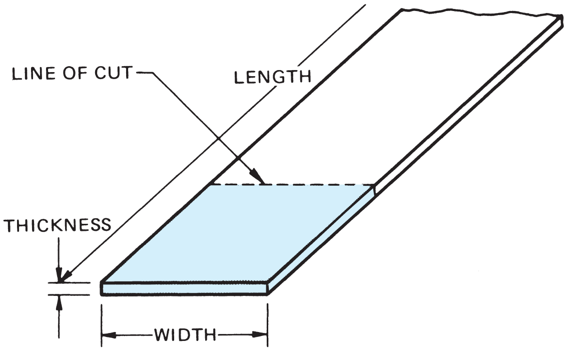


FIGURE 5.4 ■ Cutting material from flat bar stock.

Note that the word **long** is used and the × sign between the width and length dimensions is not used.

In some cases the word **flat** is used following the width dimension to reduce any possibility of a misunderstanding:

10 — ¼″ × 3″ FLAT 8″ LONG
10 — ½″ × 2¼″ FLAT 8″ LONG

If the flat stock is of the required width and thickness, then parts need only be cut to the required length.

Figure 5.5 illustrates a typical detail assembly drawing from which a bill of materials can be prepared. Sufficient information in terms of sizes and kinds of material is shown on the drawing.

The examples cited thus far are representative of bills of materials for simple objects. Other objects may be more complex and may involve circumference calculations, or may be concerned with diameter or radius dimensions rather than lengths or widths. Examples of calculations that may be required in the preparation of a bill of materials are illustrated in Figure 5.6.

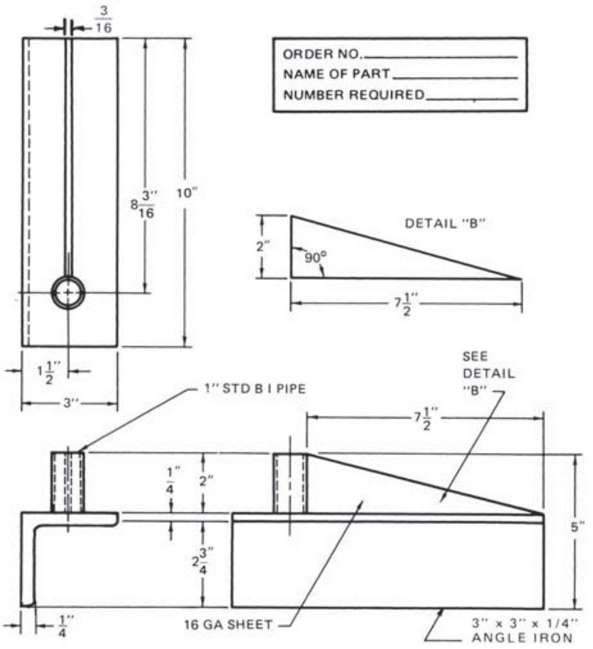
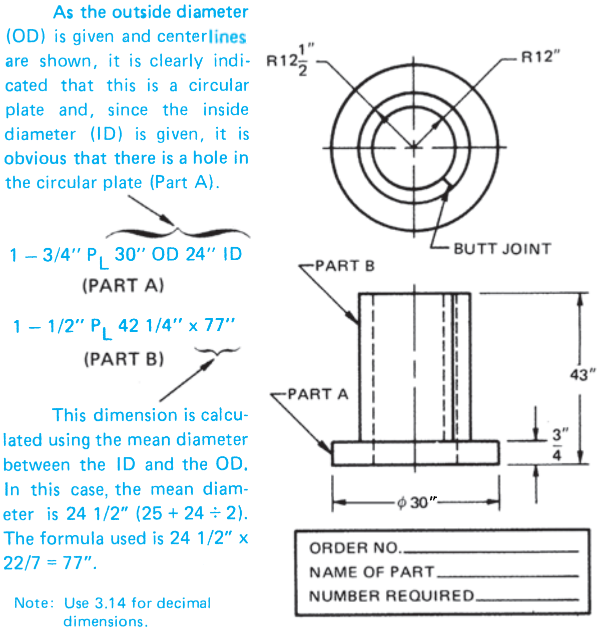


FIGURE 5.5 ■ Complete listing of materials shown on a drawing.



As the outside diameter (OD) is given and centerlines are shown, it is clearly indicated that this is a circular plate and, since the inside diameter (ID) is given, it is obvious that there is a hole in the circular plate (Part A).

This dimension is calculated using the mean diameter between the ID and the OD. In this case, the mean diameter is 24 1/2″ (25 + 24 ÷ 2). The formula used is 24 1/2″ x 22/7 = 77″.

Note: Use 3.14 for decimal dimensions.

FIGURE 5.6 ■ Calculating sizes for a bill of materials.

SPECIFYING TYPES OF STEEL

When it is necessary to specify a particular type of steel in a bill of material, it is often identified by an AISI (American Iron and Steel Institute)–SAE (Society of Automotive Engineers) classification number.

AISI–SAE refers to a standard numbering system for designating carbon and alloy steels. This system essentially indicates the nominal composition of nine basic types of steel, as follows:

1—Carbon steel
2—nickel steel
3—nickel-chromium steel
4—molybdenum steel
5—chromium steel
6—chromium-vanadium steel
7—tungsten steel
8—nickel-chromium-vanadium steel
9—silicon-magnesium steel

An AISI–SAE classification for a type of steel consists of either four or five numbers. The first number in the AISI–SAE classification system indicates the basic type of steel. The second number represents the nominal percentage of the alloying component, and the last two or three numbers indicate the nominal percentage of carbon content.

Examples of number classifications for steel and their interpretation follow:

Four-Digit Classification: 1005

1—Represents the kind of steel (carbon)
0—Indicates zero percent alloy content
05—Indicates nominal percentage of carbon content in hundredths of 1 percent (.05 carbon)

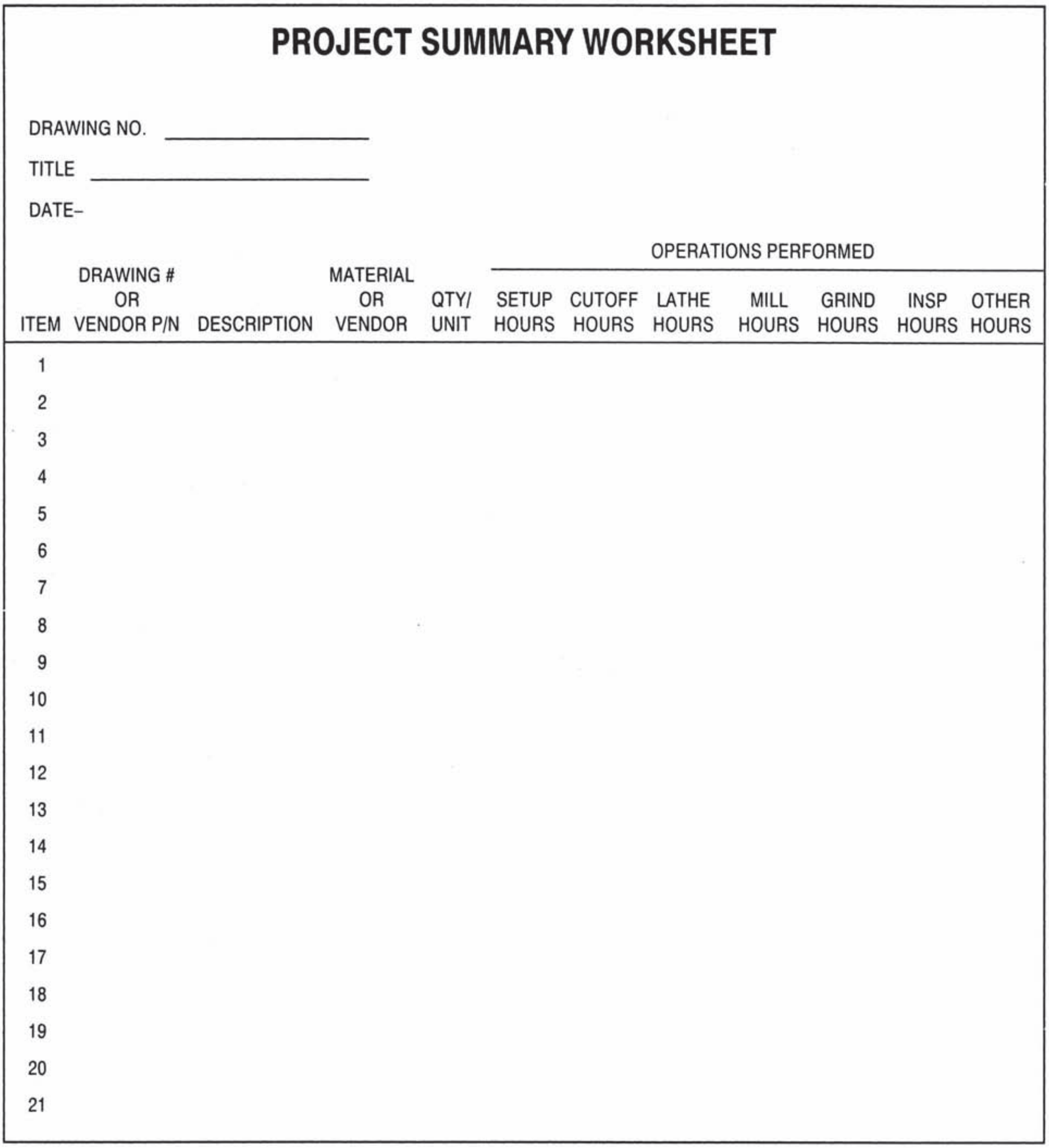
Five-Digit Classification: 22125

2—Represents the kind of steel (nickel)
2—Represents the nominal percentage of the alloying element (2% nickel)
125—Represents the nominal percentage or points of carbon (1.25 carbon)

In addition to classification by an AISI–SAE number, steels are also identified by the general terms "low carbon steel" (.30% and less carbon), "medium carbon steel" (.30% to .50%), "high carbon steel" (.50% to .90% carbon content), and "tool steel" (.80% to 1.50% carbon content). Similar standards are published by other associations and institutes. One in particular is the American Society for Testing and Materials (ASTM). This society also publishes documents related to the composition of metals. In this system, the letter "A" is used to identify ferrous metals and "B" for nonferrous metals, followed by a series of numbers representing the various elements that make up the composition of a metal.

PROJECT SUMMARY WORKSHEET

Bills of materials may also be included as a part of a Project Summary Worksheet, Figure 5.7. Many companies use these sheets in one form or another to track the progress and costs of a project. The information contained on the sheet is entered into a computer system, serving as a database for maintaining accountability of the project. To summarize, a bill of materials basically consists of the size (length, width, and thickness), the kind of material, the part name or item number, and the number of pieces required. This information may be supplemented with other information, including the shape of the material, its nominal carbon content (low, medium, or high), or an AISI–SAE identification number.



PROJECT SUMMARY WORKSHEET

DRAWING NO. ____________________

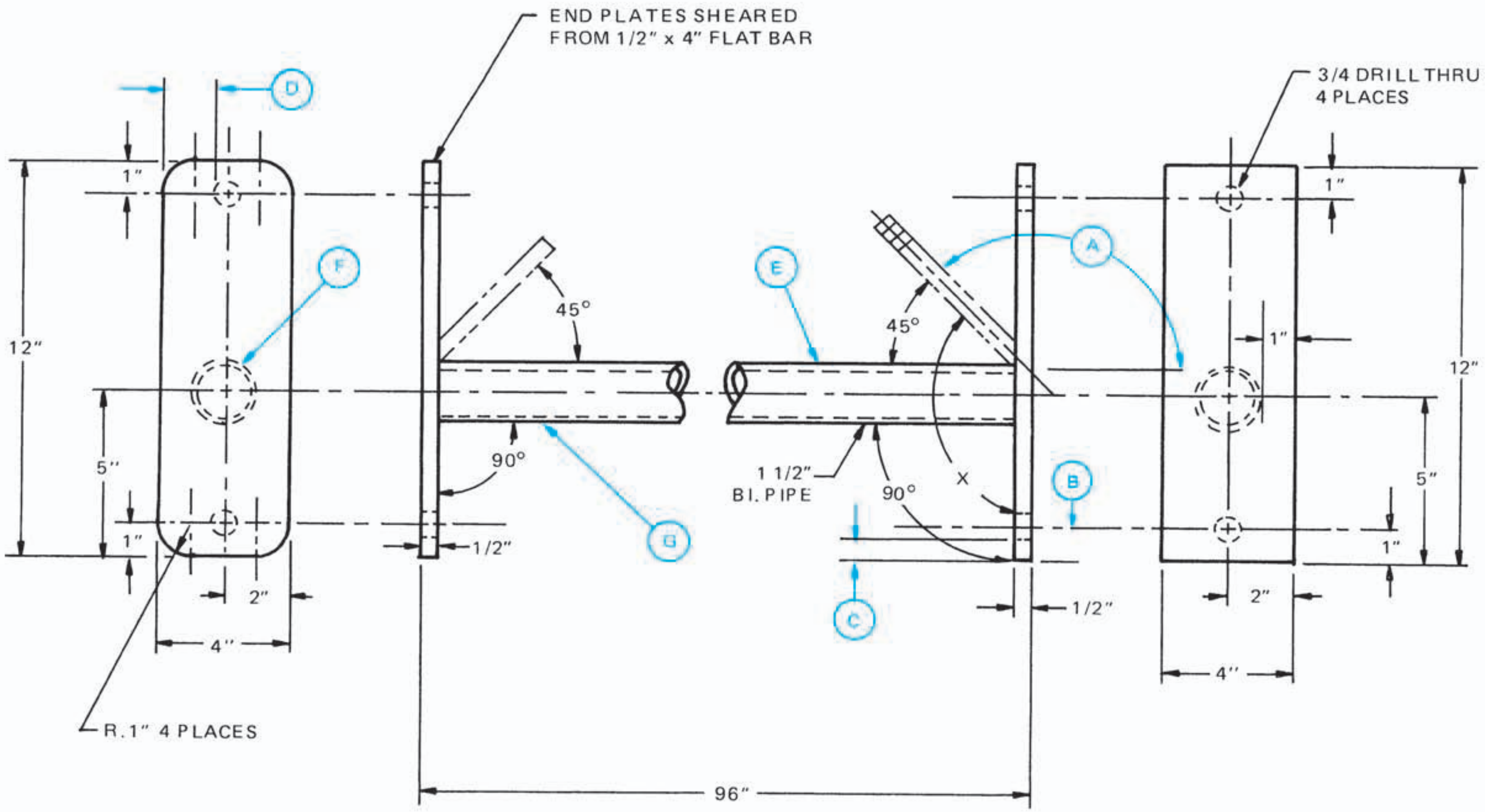
TITLE ___________________________

DATE–

					OPERATIONS PERFORMED						
ITEM	DRAWING # OR VENDOR P/N	DESCRIPTION	MATERIAL OR VENDOR	QTY/ UNIT	SETUP HOURS	CUTOFF HOURS	LATHE HOURS	MILL HOURS	GRIND HOURS	INSP HOURS	OTHER HOURS
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											

FIGURE 5.7 ■ Project summary worksheet.

NOTES



QTY.–4	TITLE– SPACER BAR
SCALE–NONE	DRAWN BY: S. ASH
MATERIAL–HOT ROLLED LOW CARBON STEEL	
B-003-A	

UNIT 5: REVIEW A

Graph paper is provided at the end of each review for your use.

Refer to the drawing, Spacer Bar, page 48.

1. How many spacer bars are required to complete the order?

2. What is the total overall length of the spacer bar?

3. How many and what size drilled hole(s) are required to complete the order? List sizes in decimal fractions.

4. What is the dimension of each of the following distances and angles:

   Ⓐ ______

   Ⓑ ______

   Ⓒ ______

   Ⓓ ______

5. What is the purpose of the phantom lines?

6. What is the total length of ½″ × 4″ flat bar required for completion of the order?

7. What is the dimension of the distance identified as Ⓔ (assume pipe wall thickness is ¼″)?

8. a. What is the nominal size of the BI pipe?

   b. What is the actual size of the BI pipe? (Note: Refer to Appendix 3.)

   c. What is the total length of BI pipe required for completion of the order?

9. Describe how the right-hand end plate differs from the left-hand end plate.

10. Line Ⓕ in the left end view represents which line in the front view?

11. How many inches of weld are required around each end of the pipe?

12. How many square inches of plate are required for each of the end plates? (Note: Include material for drilled holes.)

13. What tolerances are applied to the dimensions?

14. What is the angle of dimension “X”?

15. What is shown in error on the drawing?

16. Identify the type of line used to show the position of the end plates after they are bent.

17. What kind of material is specified for the end plates?

18. Identify the type of drawing shown.

19. a. Why is the pipe shown with a break?

____

b. Identify the symbol used for this purpose.

____

20. a. Why are three views used for this part?

____

____

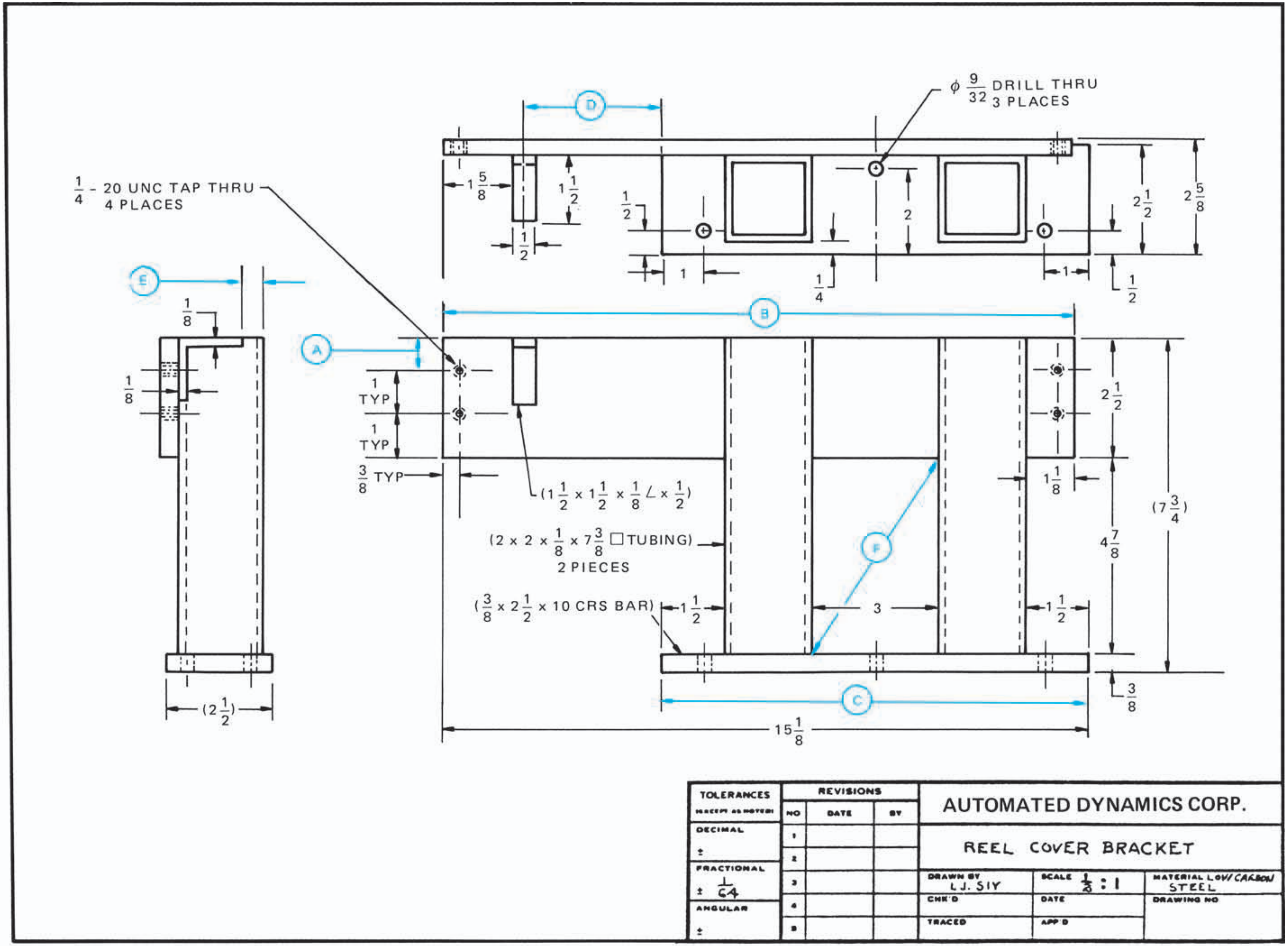
b. Identify the views shown.

____

____

21. Sketch a bottom view of the spacer bar assembly.

22. Prepare a Project Summary Worksheet using the format shown in Figure 5.7. Refer to foldout drawing number 7 “Die Stand Frame” for data that are available on the print to assist in completing the sheet. Where necessary, use hypothetical figures in conjunction with the data shown on the drawing to complete the Project Summary Worksheet.


1/4 - 20 UNC TAP THRU
4 PLACES
ϕ 9/32 DRILL THRU
3 PLACES
D
E
A
B
C
F
1 5/8
1 1/2
1/2
1/2
1
1/4
2
2 1/2
2 5/8
1
1/2
1/8
1/8
1 TYP
1 TYP
3/8 TYP
(1 1/2 x 1 1/2 x 1/8 ∠ x 1/2)
(2 x 2 x 1/8 x 7 3/8 □TUBING)
2 PIECES
(3/8 x 2 1/2 x 10 CRS BAR)
1 1/2
3
1 1/2
1 1/8
2 1/2
4 7/8
(7 3/4)
3/8
(2 1/2)
15 1/8
TOLERANCES
(EXCEPT AS NOTED)
DECIMAL
±
FRACTIONAL
± 1/64
ANGULAR
±
REVISIONS
NO
DATE
BY
1
2
3
4
5
AUTOMATED DYNAMICS CORP.
REEL COVER BRACKET
DRAWN BY
L.J. SIY
SCALE
1/8 : 1
MATERIAL LOW CARBON
STEEL
CHK'D
DATE
DRAWING NO
TRACED
APP'D

UNIT 5: REVIEW B

Refer to the drawing, Reel Cover Bracket, page 52.

1. Identify the type of drawing that is represented.

2. a. What is the total length of square tubing required for fabrication of the part?

   b. What is the size of the square tubing?

3. Does the size of the square tubing given represent a nominal or actual size?

4. a. How many tapped holes are required?

   b. What is the size and pitch of the tap to be used?

   c. Interpret the meaning of UNC.

   d. What size tap drill is to be used?

5. Sketch a right side view of the bracket.

6. What is the significance of the dimensions enclosed in the brackets?

7. Explain what is meant by TYP as shown on the drawing.

8. What are the dimensions for the following?

   Ⓐ ______________ Ⓓ ______________

   Ⓑ ______________ Ⓔ ______________

   Ⓒ ______________ Ⓕ ______________

9. Identify a line that is missing on the drawing and give its location.

10. What kind of steel is specified for making the bracket?

11. Prepare a bill of materials for the bracket.

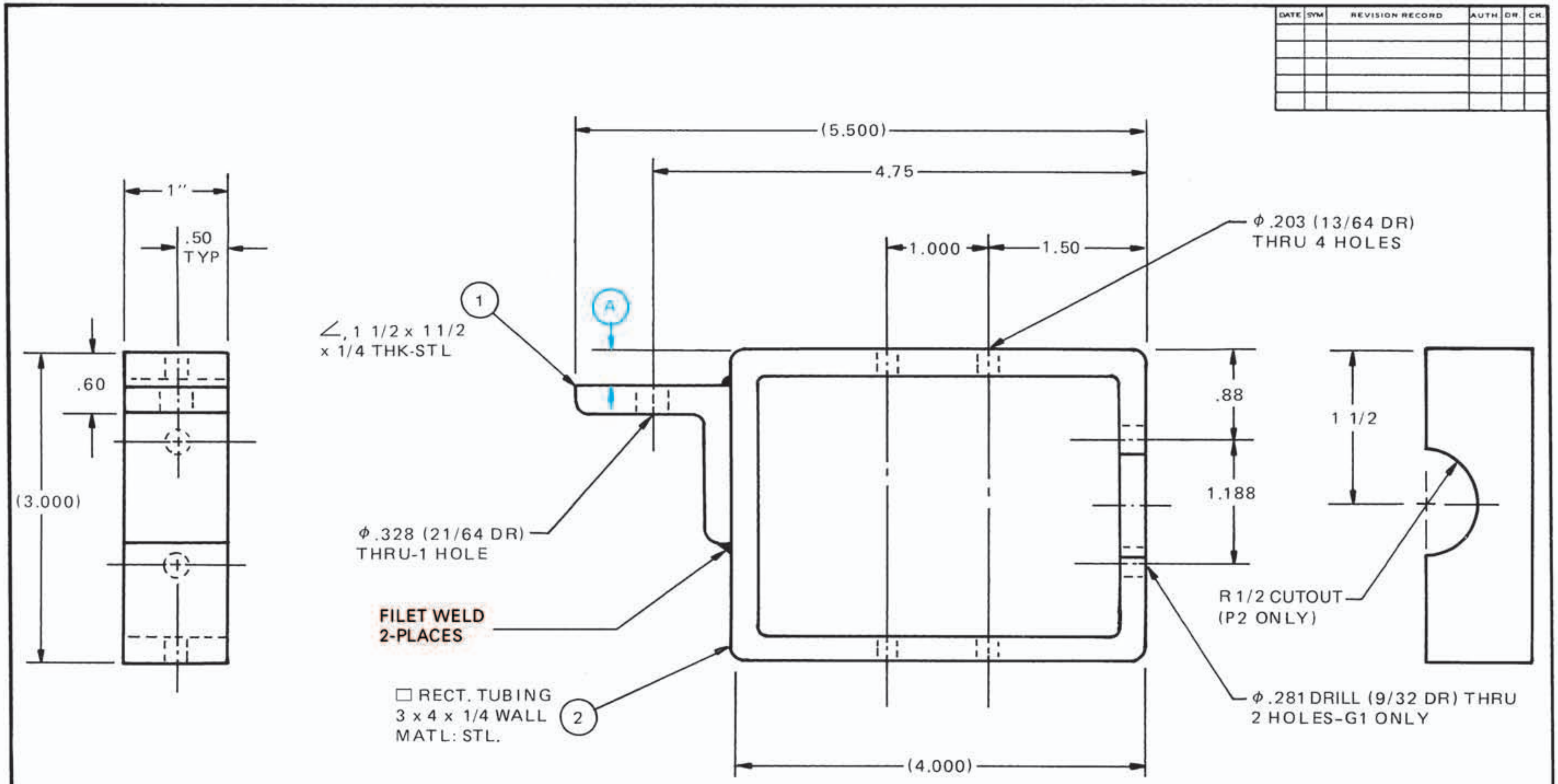
Bill of Materials

No.	Material	Size

12. Sketch a bottom view of the bracket.

13. a. List a location dimension that is missing on the drawing.

    b. Identify the view in which it is missing.


DATE
SYM
REVISION RECORD
AUTH
DR.
CK.
(5.500)
4.75
1"
.50 TYP
1.000
1.50
ϕ .203 (13/64 DR) THRU 4 HOLES
①
A
∠, 1 1/2 x 1 1/2 x 1/4 THK-STL
.60
(3.000)
.88
1 1/2
1.188
ϕ .328 (21/64 DR) THRU-1 HOLE
FILET WELD 2-PLACES
R 1/2 CUTOUT (P2 ONLY)
□ RECT. TUBING 3 x 4 x 1/4 WALL MATL: STL.
②
ϕ .281 DRILL (9/32 DR) THRU 2 HOLES-G1 ONLY
(4.000)

QTY		
3	①	ITEM 1-INCL. 2 HORIZONTAL HOLES
3	②	ITEM 1-INCL. 4 VERTICAL HOLES & CUTOUT

TOLERANCES (EXCEPT AS NOTED)	REVISIONS			U.S. COMPOSITES		
	NO	DATE	BY			
DECIMAL XXX ± .010 ±XX ± .020	1			CLAMP BRACKET		
	2					
FRACTIONAL ± 1/64	3			DRAWN BY	SCALE FULL	MATERIAL AS SHOWN
	4			CHK'D	DATE	DRAWING NO
ANGULAR ± 1/2°	5			TRACED	APP'D	RAR450-0025

UNIT 5: REVIEW C

Refer to the drawing, Clamp Bracket, page 56.

1. a. Identify the three views shown on the drawing.

   b. List the location dimensions found on each of these views.

   c. List the total number of parts to be made.

2. a. What is the angular tolerance specified?

   b. What is the common fraction tolerance specified?

   c. What is the significance of the tolerance xx ± .020?

3. List the reference dimensions shown on the drawing.

4. List the tolerance(s) applicable to the following dimensions:

   .88 ______________

   1.188 ______________

   1½ ______________

5. What is the total length of rectangular tubing required? Allow ¼″ for finishing and cutting each piece to complete all the parts.

6. What is the total length of angle material required to complete all the parts? Allow ⅛″ for cutting and finishing each piece.

7. What are the inside dimensions of the rectangular tubing?

8. Are the dimensions of the rectangular tubing nominal or actual?

9. On the drawing, apply a .50 dimension where it is so implied by the .50 TYP dimension.

10. What is the maximum allowable size for dimension 5.500?

11. Prepare a two-view sketch for each of the parts.

    P1

    P2

12. Prepare a bill of materials for P1 and P2. Show each as a separate bill.

    P1

    P2

13. What do the following symbols signify?

    a. □ ______________

    b. ∠ ______________

    c. ⌀ ______________

    d. R ______________

14. a. What is the diameter size of the cutout?

    b. What is the tolerance size(s) of the cutout?

6 UNIT

Structural Shapes

There are many types and styles of structural metal shapes used in the welding industry. Most weldments use combinations of these shapes. In reading prints, it is essential to know the shapes available and how their sizes are specified. The Appendix contains size specifications of common structural shapes.

As discussed in Unit 5, sheet metal is 3⁄16″ or less in thickness and plate is greater than 3⁄16″ thick. However, these measurements will vary slightly from manufacturer to manufacturer. Sheet thickness may be given as a fraction of an inch (usually as a decimal fraction) or as a gage number. Plate thickness is given as a common fraction of an inch.

A variety of standard gages is used to measure the thickness of various structural metal shapes. The most commonly used gage is the Manufacturer's Standard Gage for Sheet Steel, formerly the U.S. Standard Sheet Metal Gage. Other common gages are the American Wire Gage (AWG) or Brown and Sharpe Wire Gage for sheets of brass, phosphor-bronze, aluminum, and German silver; and the Birmingham Wire Gage (BWG) for strip steel, steel bands, hoop steel, crucible spring sheet, and sheet copper.

Table 6.1 gives the standard gages used for wire, sheet, and plate. Note that several of the gages have more than one name.

Figure 6.1 illustrates a standard sheet metal gage. The openings along the circumference are used to measure the thickness of sheet or plate, or the diameters of wire. The partial circles or holes in back of the openings are for clearance purposes only.

The size of the slot opening is indicated by a gage number placed near each slot on one side of the gage. The opposite side of the gage gives this size as a decimal fraction. Sheet metal thickness is often specified with the gage used, the gage number, and its decimal size. This procedure is followed to reduce the possibility of error in the selection of the sheet.

The common method of specifying sheet and plate is to give the thickness (including gage used when it is sheet), width, and length in that order. The following examples show how sheet and plate sizes are specified.

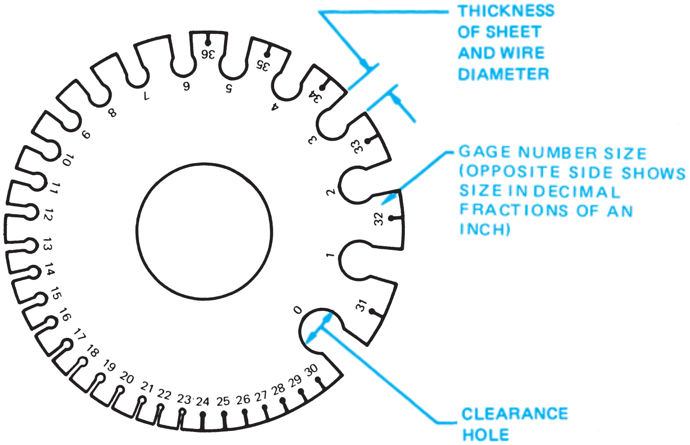

THICKNESS OF SHEET AND WIRE DIAMETER
GAGE NUMBER SIZE (OPPOSITE SIDE SHOWS SIZE IN DECIMAL FRACTIONS OF AN INCH)
CLEARANCE HOLE
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0

FIGURE 6.1 ■ Sheet metal and wire gage.

Thickness		Width		Length
Sheet No. 14 AWG (.0641)	×	4′ (or 48″)	×	6′ (or 72″)
Plate ¼″	×	3′ (or 36″)	×	8′ (or 96″)

Decimel Equivalents

Gage No.	Birmingham Wire (BWG.) also Stubs Iron Wire	Brown and Sharpe or American Wire (AWG.)	Manufacturer's Standard Mfr's. Thickness for Steel	British Imp. Standard Wire (SWG.)	Stand. Steel Wire Gages or Washburn and Moen	Stubs Steel Wire	U.S. Standard (old)
7-0	—	—	—	.500	.4900	—	.5000
6-0	—	.5800	—	.464	.4615	—	.4687
5-0	.500	.5165	—	.432	.4305	—	.4375
4-0	.454	.4600	—	.400	.3938	—	.4062
3-0	.425	.4096	—	.372	.3625	—	.3750
2-0	.380	.3648	—	.348	.3310	—	.3437
0	.340	.3249	—	.324	.3065	—	.3125
1	.300	.2893	—	.300	.2830	.227	.2812
2	.284	.2576	—	.276	.2625	.219	.2656
3	.259	.2294	.2391	.252	.2437	.212	.2500
4	.238	.2043	.2242	.232	.2253	.207	.2344
5	.220	.1819	.2092	.212	.2070	.204	.2187
6	.203	.1620	.1943	.192	.1920	.201	.2031
7	.180	.1443	.1793	.176	.1770	.199	.1875
8	.165	.1285	.1644	.160	.1620	.197	.1719
9	.148	.1144	.1495	.144	.1483	.194	.1562
10	.134	.1019	.1345	.128	.1350	.191	.1406
11	.120	.0907	.1196	.116	.1205	.188	.1250
12	.109	.0808	.1046	.104	.1055	.185	.1094
13	.095	.0720	.0897	.092	.0915	.182	.0937
14	.083	.0641	.0747	.080	.0800	.180	.0781
15	.072	.0571	.0673	.072	.0720	.178	.0703
16	.065	.0508	.0598	.064	.0625	.175	.0625
17	.058	.0453	.0538	.056	.0540	.172	.0562
18	.049	.0403	.0478	.048	.0475	.168	.0500
19	.042	.0359	.0418	.040	.0410	.164	.0437
20	.035	.0320	.0359	.036	.0348	.161	.0375
21	.032	.0285	.0329	.032	.0317	.157	.0344
22	.028	.0253	.0299	.028	.0286	.155	.0312
23	.025	.0226	.0269	.024	.0258	.153	.0281
24	.022	.0201	.0239	.022	.0230	.151	.0250
25	.020	.0179	.0209	.020	.0204	.148	.0219
26	.018	.0159	.0179	.018	.0181	.146	.0187
27	.016	.0142	.0164	.016	.0173	.143	.0172
28	.014	.0126	.0149	.015	.0162	.139	.0156
29	.013	.0113	.0135	.014	.0150	.134	.0141
30	.012	.0100	.0120	.012	.0140	.127	.0125
31	.010	.0089	.0105	.012	.0132	.120	.0109
32	.009	.0080	.0097	.011	.0128	.115	.0102
33	.008	.0071	.0090	.010	.0118	.112	.0094
34	.007	.0063	.0082	.009	.0104	.110	.0086
35	.005	.0056	.0075	.008	.0095	.108	.0078
36	.004	.0050	.0067	.008	.0090	.106	.0070
37	—	.0045	.0064	.007	.0085	.103	.0066
38	—	.0040	.0060	.006	.0080	.101	.0062
39	—	.0035	—	.005	.0075	.099	—
40	—	.0031	—	.005	.0070	.097	—

TABLE 6.1 ■ Standard gages—wire, sheet, plate.

Other forms of structural metals and the methods of specifying their sizes are presented in Table 6.2.

When considering size specifications, remember that steels are classified as **hot-rolled** or **cold-rolled.** Hot-rolled varieties are slightly oversized and have slightly rounded corners. Cold-rolled steels are more precise in size and have square corners. In addition, there are size specifications for certain structural shapes: S-beams (formerly called I-beams), H-beams, wide-flange (W) beams, and pipe are only approximate (nominal).

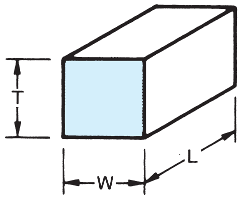
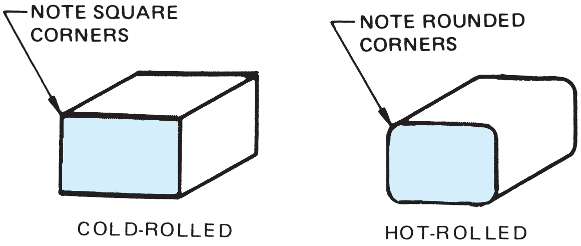
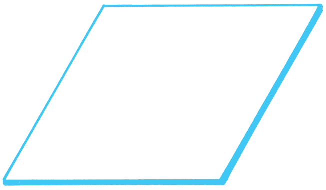
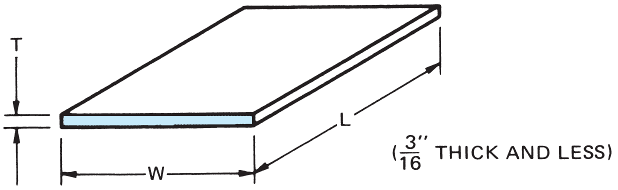
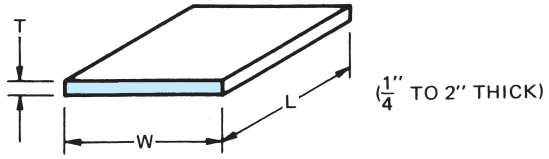
Structural Shape	Size Specifications
 **SQUARE BAR**  NOTE SQUARE CORNERS NOTE ROUNDED CORNERS COLD-ROLLED HOT-ROLLED **RECTANGULAR BAR**	T x W x L (SYMBOL ☐ or ⧄) T = Thickness in inches W = Width in inches (same size as thickness for square bar) L = Length in feet and/or inches Expressed as: 1/2" x 1/2" x 18" or 1/2" square x 18" or 1/2" ☐ x 18" or ⧄ 1/2" x 18" or 1/2" ☐ 18" long NOTE: In machine shop practice, dimensions less than 72" are generally given in inches, and in feet and inches thereafter. In structural practice, dimensions of 12" and over are given in feet and inches.
 SHEET	Gage x W x L Gage (thickness) is expressed as a gage number or decimal fraction of an inch. W = Width in inches L = Length in feet or inches Expressed as: U.S. Std. Gage #7 x 36" x 96" or .179 Sheet x 3' x 8' or USSG #7 x 36" x 96"
 **STRIP OR BAND**	T x W x L T = Thickness as a fraction of an inch (usually expressed as a decimal fraction) or a gage number (for strips 3/16" thick and less). W = Width in inches (usually does not exceed 6") L = Length in feet and/or inches Expressed as: 1/8" x 2" x 8' or 1/8" x 2" x 8' long or .125" x 2" x 8'
 **PLATE OR FLAT BAR**	T x W x L (SYMBOL = PL) T = Thickness as a fraction of an inch or in decimals (1/4" to 2" or .25" to 2") W = Width in inches (usually does not exceed 6" for flat bar) Expressed as: 1/4" x 6" x 10' or 1/4" x 6" x 10' long or .25" x 6" x 10' PL

TABLE 6.2 ■ Size specifications for structural shapes.

Weight is another specification applied to certain structural shapes and is often included with the size specifications. The weight is given because the cross-sectional areas of two similar shapes may vary although the overall sizes are the same.

Weight specifications are applied to channels, S-beams, M-beams, W-beams, and HP-beams. The specification is given in pounds per linear foot (lb/lin ft).

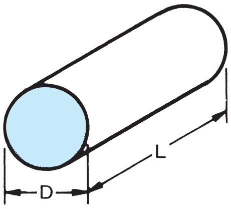
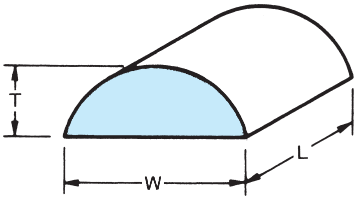
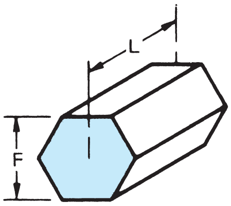
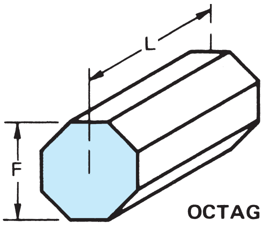
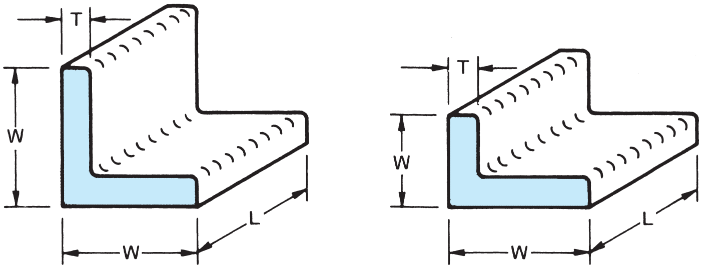
Structural Shape	Size Specifications
 ROUND BAR	D x L (SYMBOL = ○ or Ø) D = Diameter in inches (fraction or decimal) L = Length in feet and/or inches Expressed as: 1" round 8'6" long or 1" ○ x 8'6" or Ø 1" x 8'6"
 HALF OVAL BAR	T x W x L T = Thickness in inches (fraction or decimal) W = Width in inches L = Length in feet and/or inches Expressed as: 1" x 2" half oval x 16' or 1" x 2" half oval 16' long
 HEXAGON BAR	F x L (SYMBOL = HEX) F = Distance across flats in inches (fraction or decimal) L = Length in feet and/or inches Expressed as: $^{3}/_{4}$" HEX x 8" or $^{3}/_{4}$" HEX 8" long or .750" HEX x 10'
 OCTAGON BAR	F x L F = Distance across flats in inches L = Length in feet and/or inches (fraction or decimal) Expressed as: 1$^{1}/_{2}$" octagon x 10' or 1$^{1}/_{2}$" octagon 10' long or 1.500 octagon x 10'
 EQUAL LEGS UNEQUAL LEGS ANGLE IDENTIFIED BY THE SYMBOL ∠	W x W x T x L W = Width of leg in inches T = Thickness of leg in inches L = Length in feet and/or inches Expressed as: equal legs 2" x 2" x $^{1}/_{4}$" angle x 18' or 2" x 2" x $^{1}/_{4}$" L x 18' or ∠2" x 2" x $^{1}/_{4}$" – 18' or ∠2" x 2" x $^{1}/_{4}$" 18' long Unequal legs or 2" x 1" x $^{3}/_{16}$" angle x 18' or 2" x 1" x $^{3}/_{16}$" L x 18' or ∠2" x 1" x $^{3}/_{16}$" –18' or ∠2" x 1" x $^{3}/_{16}$" 18' long

TABLE 6.2 ■ Size specifications for structural shapes. (continued)

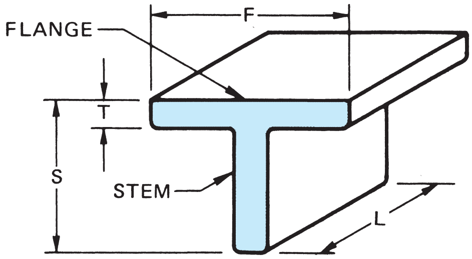
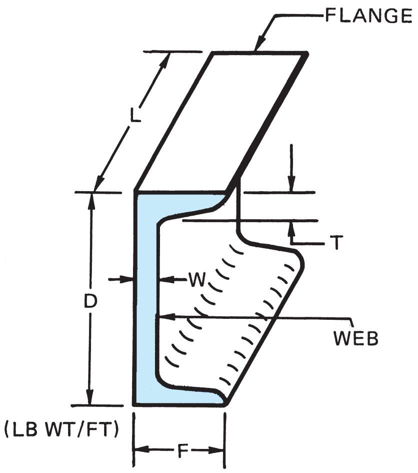
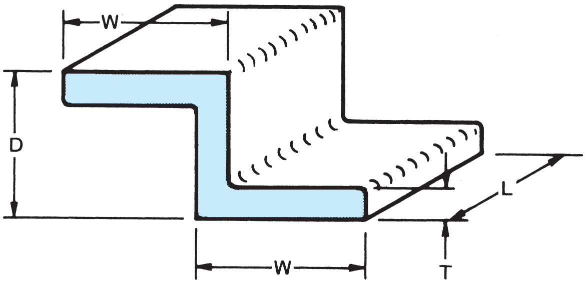
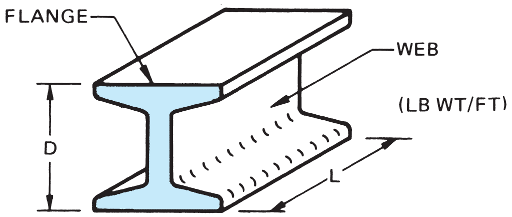
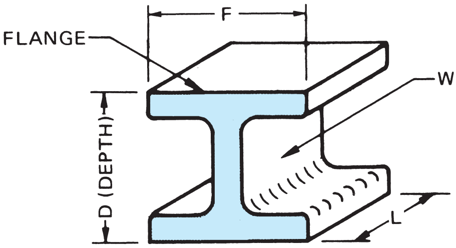
Structural Shape	Size Specifications
 **TEE** IDENTIFIED BY THE LETTER – T	F x S x T x L or TS x wt/ft x L F = Width of flange in inches S = Width of stem in inches T = Thickness of flange in inches L = Length in feet and/or inches WT = Tee cut from W-beam MT = Tee cut from M-beam HP = Tee cut from wide flange beam Expressed as: 2" x 1^{1}/2" x ^{1}/4" Tee x 18' or MT1^{1}/2" x 3.12 x 18' (3.12 represents pounds per linear ft) or WT18 x 150 x 18' long (150 represents pounds per linear ft) or MT4 x 13 x 16' long (13 represents pounds per linear ft)
 **CHANNEL** IDENTIFIED BY THE LETTERS – C OR – MC	D x F x T x L or CD x wt/ft x L D = Depth of channel in inches F = Width of flange in inches T = Thickness of flange W = Thickness of web L = Length in inches and/or feet C = Standard shape MC = Miscellaneous shape Expressed as: 3" x 1.410" x .170 channel x 15' or C3" x 4.1 x 15' (4.1 represents pounds per linear ft) or MC6" x 12 x 14' (12 represents pounds per linear ft) or C12 x 6" x 14'
 **ZEE** IDENTIFIED BY THE LETTER – Z	W x D x W x T x L or LD x wt/ft x L W = Width of flange in inches D = Depth of stem in inches T = Thickness of flange L = Length in feet and/or inches Expressed as: 1^{3}/4" x 1^{3}/4" x 1^{3}/4" x ^{3}/16" Zee x 18' or ⅂1^{3}/4" x 1^{3}/4" x 1^{3}/4" x ^{3}/16" x 18' or 1^{3}/4" x 1^{3}/4" x 1^{3}/4" x ^{3}/16" ⅂ x 18' or 1^{3}/4" x 1^{3}/4" x 1^{3}/4" x ^{3}/16" ⅂18' long or ⅂1 ^{3}/4"x 1 ^{3}/4" x 2.8 x 18' (2.8 represents pounds per linear ft)

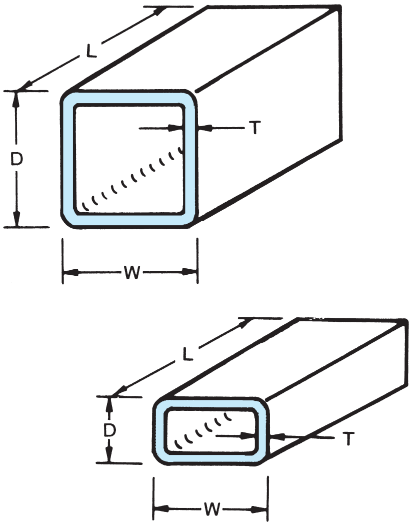
TABLE 6.2 ■ Size specifications for structural shapes. (continued)

<table>
<tr><th>Structural Shape</th><th>Size Specifications</th></tr>
<tr><td>


STANDARD S-BEAM (I-BEAM)
IDENTIFIED BY THE LETTER – S

ALSO **MISCELLANEOUS BEAM (M-BEAM)**
IDENTIFIED BY THE LETTER – M
</td><td>
D x L or SD x wt/ft x L
D = Depth of beam in inches
L = Length in feet and/or inches
SD = S-beam depth
LB WT/FT = Pounds per linear foot
Expressed as: 4" S-beam x 6'
or 4" S x 6'
or 4" S x 8 x 6' (8 represents weight in pounds per linear ft)
or 4" S x 8 x 6' long
or S 4" x 8 x 6'
NOTE: Miscellaneous beams are expressed similarly except for the identifying letter (M).
</td></tr>
<tr><td>


WIDE-FLANGE BEAM
IDENTIFIED BY THE LETTER – W
MISCELLANEOUS AND HP BEAMS

ALSO **BEARING BEAM (HP BEAM)**
IDENTIFIED BY THE LETTERS – HP
</td><td>
D x F x wt/ft x L
D = Depth in inches
F = Width of flange in inches
L = Length in feet and/or inches
Expressed as: 24" x 8" W – beam
or 24" W – beam, 120 lb/ft x 20'
or 24" W 120, x 20' (120 represents weight in pounds per linear ft)
or 24" W beam
or W 24" x 120 x 20'
The same size specifications apply as for standard and wide-flange beams except for the beam identification letter(s).
For example: M4 x 13.0 x 10'
or HP14 x 117 x 10' long
NOTE: Bearing beams are expressed similarly except for the letter designation (HP).
</td></tr>
<tr><td>


SQUARE AND RECTANGULAR TUBING
</td><td>
There are two basic types of hollow structural steel with square corners: square and rectangular. The size is determined by the width and the depth.
W x D x T x L
W = Width in inches
D = Depth in inches
T = Thickness in inches
L = Length in feet and/or inches
Expressed as: 1" x 1" x .125" sq. tubing x 10'
or 1" x 1" x .125" □ x 10'
or 1" x 1" x .125" sq. tubing, 10' long
For Square Tubing
or 2" x $1\frac{1}{4}$" x .083" x 8'
or Rectangular tubing $1\frac{1}{2}$" x 1" x 0.65" x 6"
or Rectangular tubing 2 x $1\frac{1}{2}$ x 11 gage x 12' long
or $1\frac{1}{2}$ x $\frac{3}{4}$ x 14 x 10' (14 signifies gage size of .083")
For Rectangular Tubing
or $1\frac{1}{2}$" x $\frac{3}{4}$" x 14 ▭ x 10'
</td></tr>
</table>

TABLE 6.2 ■ Size specifications for structural shapes. (continued)

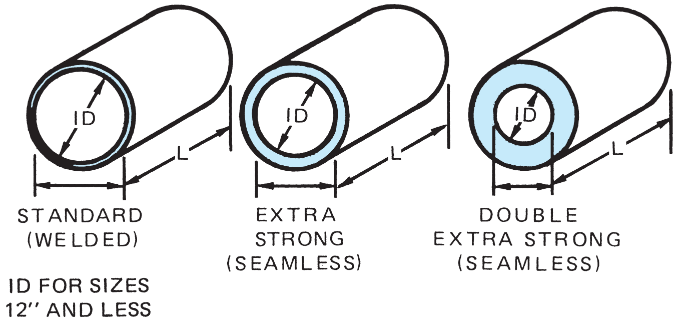
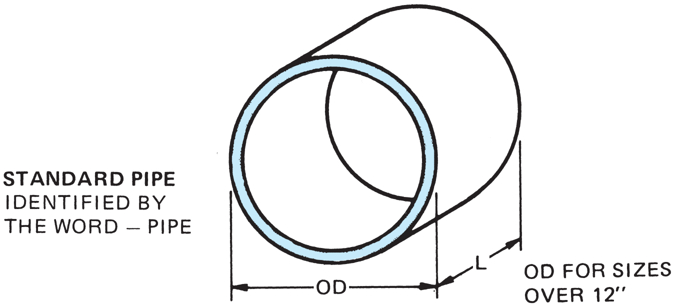
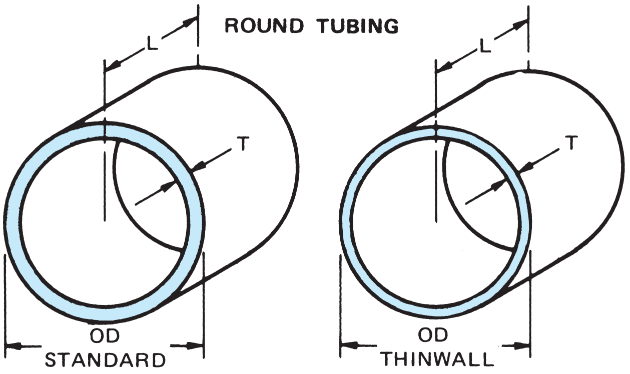
Structural Shape	Size Specifications
PIPE  ID L STANDARD (WELDED) EXTRA STRONG (SEAMLESS) DOUBLE EXTRA STRONG (SEAMLESS) ID FOR SIZES 12" AND LESS  STANDARD PIPE IDENTIFIED BY THE WORD – PIPE OD L OD FOR SIZES OVER 12"	There are three basic types of pipe. Nominal sizes for these types are determined by the inside diameter except when the diameter exceeds 12", in which case the size is determined by the outside diameter. ID x L (12" D and test) OD x L (over 12" D) ID = Inside diameter in inches OD = Outside diameter in inches L = Length in inches and/or feet STD = Standard Nominal = Approximate size XS = Extra strong XXS = Double extra strong Expressed as: 5" standard pipe x 8' (5" represents nominal ID size) or 14" standard pipe x 8' (14" represents nominal OD size) or 14" STD pipe x 8' long or 5" extra strong pipe x 8' or pipe XS 5" x 8' or 5" double extra strong pipe x 8' or 5" XXS pipe x 8' or 5" standard pipe 8' long or pipe 5" STD x 8'
 	There are two basic types of tubing: standard and thinwall. The size is always determined by the outside diameter and the wall thickness. OD = Outside diameter in inches T = Wall thickness in decimal fractions of an inch L = Length in feet and/or inches STD = Standard Expressed as: 3" x .065" x 10', standard tubing or STD tubing or 3" x .024" x 10', thinwall or 3" standard tubing x .065", 10' long or 3" STD tubing x .065" x 10'

TABLE 6.2 ■ Size specifications for structural shapes. (concluded)

COMMON STRUCTURAL SHAPES

The following is an overview of structural metal shapes commonly used in the fabrication of weldments. Figure 6.2 and Figure 6.3 show these shapes. Table 6.2 describes how size specifications are given for common shapes.

When ordering structural metal, reference is made to manufacturers' catalogs. These catalogs contain tables with a listing of the sizes available for various shapes, including the weight per linear foot.

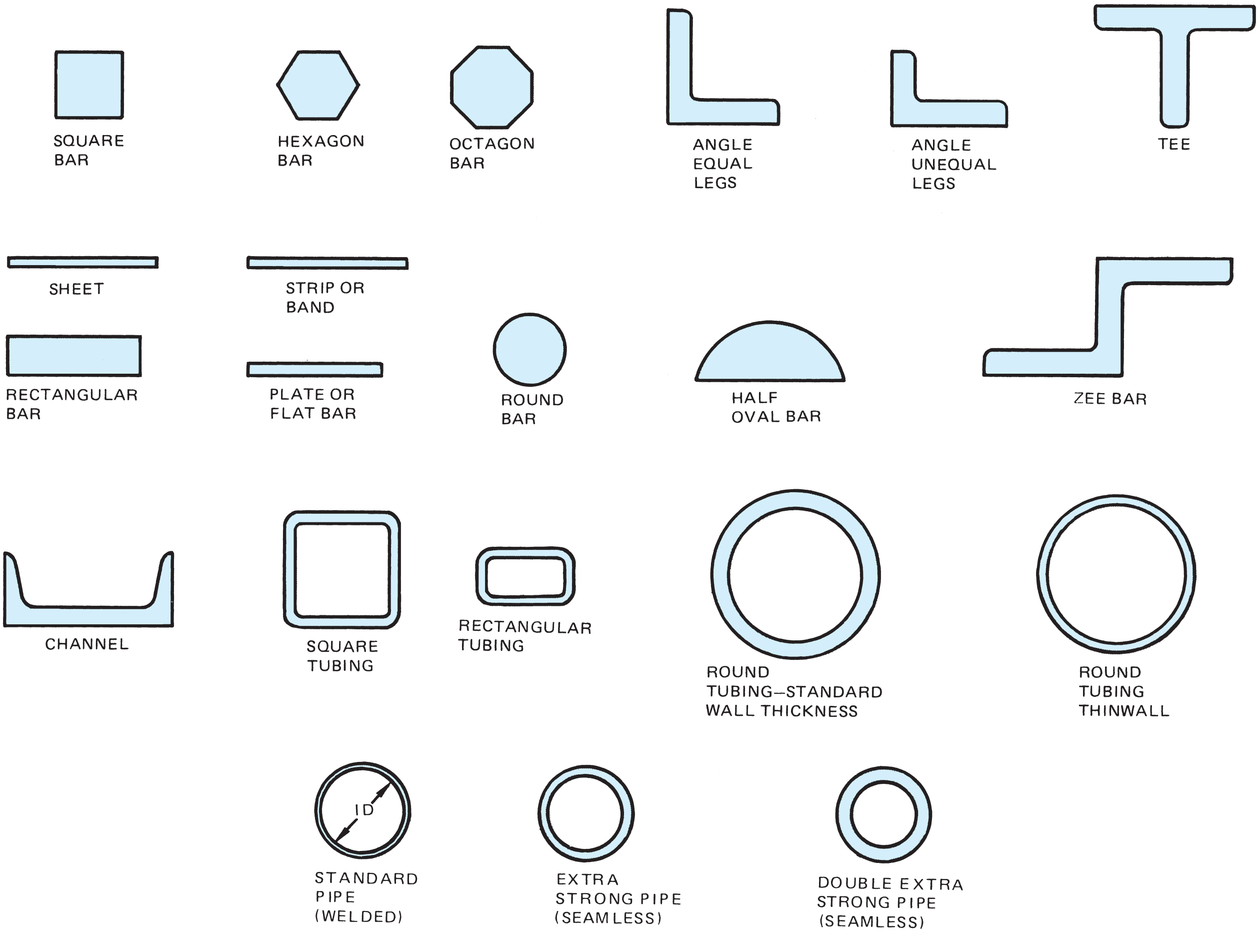


FIGURE 6.2 ■ Common structural metal shapes.

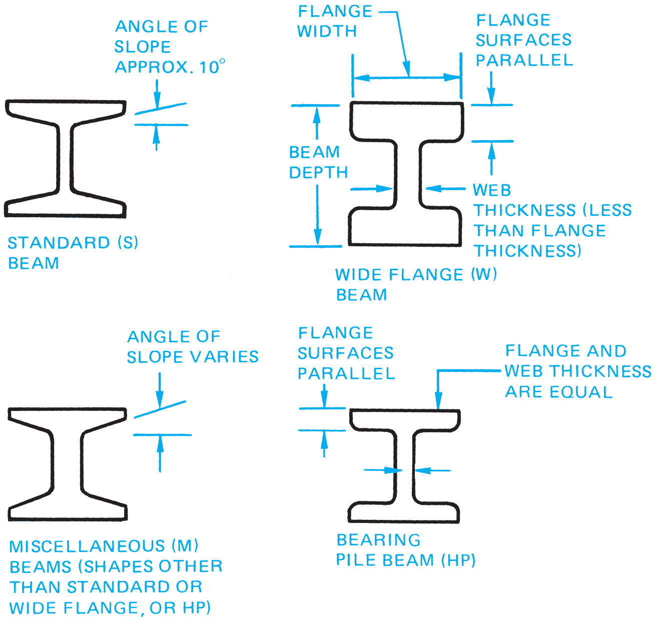

ANGLE OF SLOPE APPROX. 10°
STANDARD (S) BEAM
FLANGE WIDTH
FLANGE SURFACES PARALLEL
BEAM DEPTH
WEB THICKNESS (LESS THAN FLANGE THICKNESS)
WIDE FLANGE (W) BEAM
ANGLE OF SLOPE VARIES
MISCELLANEOUS (M) BEAMS (SHAPES OTHER THAN STANDARD OR WIDE FLANGE, OR HP)
FLANGE SURFACES PARALLEL
FLANGE AND WEB THICKNESS ARE EQUAL
BEARING PILE BEAM (HP)

FIGURE 6.3 ■ Structural beam shapes.

Sizes listed for many structural shapes are only nominal sizes. This means that an approximate size, rather than the actual size, is represented by the catalog size designation. For example, the designation of a wide-flange beam (W) is shown as W10 × 112. The letter "W" signifies a wide-flange beam, the number 10 indicates it has a depth of 10″, and the figure 112 signifies a weight of 112 pounds per linear foot. However, the actual size of the depth dimension is 11⅜″, which is one of the items of information provided in the table for wide flange beams. Refer to Appendix 2.

Structural beams are classified into four shapes:

1. Standard beams (or I-beams) identified by the letter "S."
2. Wide-flange beams, identified by the letter "W." When formed by welding, the identification is "WW."
3. Miscellaneous beams identified by the letter "M." These beams may also be identified as "Jr.," "H," or "Light Beams."
4. Bearing pile beams, identified by the letters "HP."

The material of which the structural shape is made is identified on the drawing or in the specifications. Sample notes are as follows:

NOTE: ALL 2″ SQUARE TUBING TO BE WELDED COLD-ROLLED STEEL

MATERIAL: ALL RECTANGULAR TUBING TO BE SEAMLESS COLD-DRAWN STEEL

Pipe is also sized by applying a schedule number as a part of the size specification. There are 11 schedules that are commonly used: 5, 10, 20, 30, 40, 50, 60, 80, 100, 120, and 160. The schedule numbers represent the strength of pipe and refer to its wall thickness. A study of the pipe schedule table in Appendix 3 will show that the higher the schedule number, the greater the wall thickness of the pipe. Note that the table uses the abbreviations E.H. and DBLE.H., which signify extra heavy and extra extra heavy in place of extra strong (x-strong) and extra extra strong (xx-strong). When specifying certain pipe sizes, schedule numbers may be used in place of standard, extra strong, or double extra strong designations. Examples of pipe sizes using pipe schedule numbers follow:

Example 1:

2″ schedule 40 × 10′ welded wrought steel pipe in place of
2″ standard welded wrought steel pipe × 10′

Example 2:

3″ schedule 80 × 10′ seamless wrought steel pipe in place of
3″ extra strong seamless wrought steel pipe × 10′

Standard abbreviations that are used to identify the kinds of metal are given in Table 6.3.

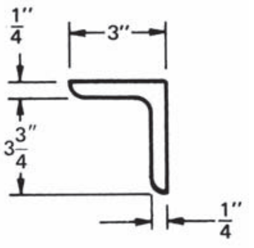
Note that pipe sizes may also be designated in metric units (mm). Refer to Appendix 4, page 392.

Alloy Steel	AL STL	Hot-Rolled Steel	HRS
Aluminum	AL	Low-Carbon Steel	LCS
Brass	BRS	Magnesium	MAG
Bronze	BRZ	Malleable Iron	MI
Cast Iron	CI	Nickle Steel	NS
Cold-Drawn Steel	CDS	Stainless Steel	SST
Cold-Finished Steel	CFS	Steel	STL
Cold-Rolled Steel	CRS	Tool Steel	TS
High-Carbon Steel	HCS	Tungsten	TU
High-Speed Steel	HSS	Wrought Iron	WI

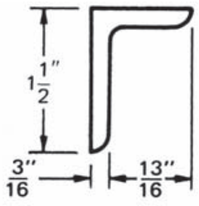
TABLE 6.3 ■ Material abbreviations.

UNIT 6: REVIEW A

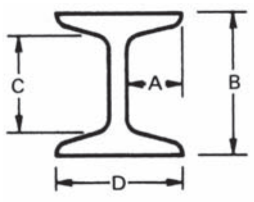
1. What thickness limit classifies metal as being sheet?
2. What is the decimal size of 14 AWG sheet?
3. What is the name of a gage used to measure nonferrous sheet metal?
4. What specifications are necessary for ordering a standard size of sheet iron?
5. What other item of stock can be measured with a sheet metal gage?
6. How is plate thickness specified?
7. Which is more accurate in size, hot-rolled or cold-rolled stock?
8. How can hot-rolled stock be distinguished from cold-rolled stock?
9. What is a piece of ½″ × 1″ × 6″ long stock commonly called?
10. How is the size of round steel or cast iron determined?
11. How is the size of hexagon steel determined?
12. What is the size specification of this angle iron?



13. What is the size specification of the angle iron below?

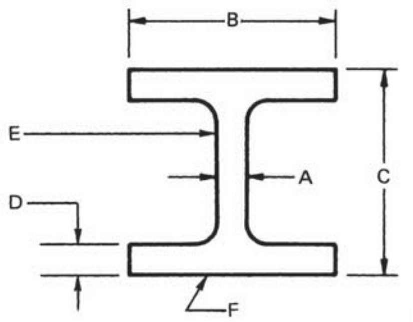


14. Which dimension(s) determine(s) the size of this S-beam?



15. Why is a weight specification applied to an S-beam?
16. a. What terms are applied to the parts of the wide-flange beam represented by letters E and F?

    b. Identify the sizes represented by the letters A, B, C, and D.



A = ____________

B = ____________

C = ____________

D = ____________

E = ____________

F = ____________

17. Sketch the symbols for:

    a. Square tubing

    b. Rectangular tubing

18. What is the difference between a standard S-beam and a wide-flange beam?

19. What is the difference between a wide-flange beam and an M-beam?

20. What dimensions do S-beams, wide-flange beams, and M-beams have in common?

21. What are the similarities between an HP beam and a wide-flange beam?

22. Write the size specification for a piece of 3″ hollow, square tubing ¼″ thick by 12′ long.

23. Explain the following abbreviations.

XS =

XXS =

HRS =

CRS =

WI =

LCS =

CI =

AL–STL =

AL =

HSS =

TS =

24. Write the size specification for an unequal leg angle including length. Use hypothetical sizes. Identify what each size represents.

25. a. What metric pipe size is approximately equivalent to a U.S. Customary pipe size of ¾″? Refer to Appendix 4.

b. What does NPS ¼ signify?

26. With reference to structural beam S, what do the following letters represent?

M =

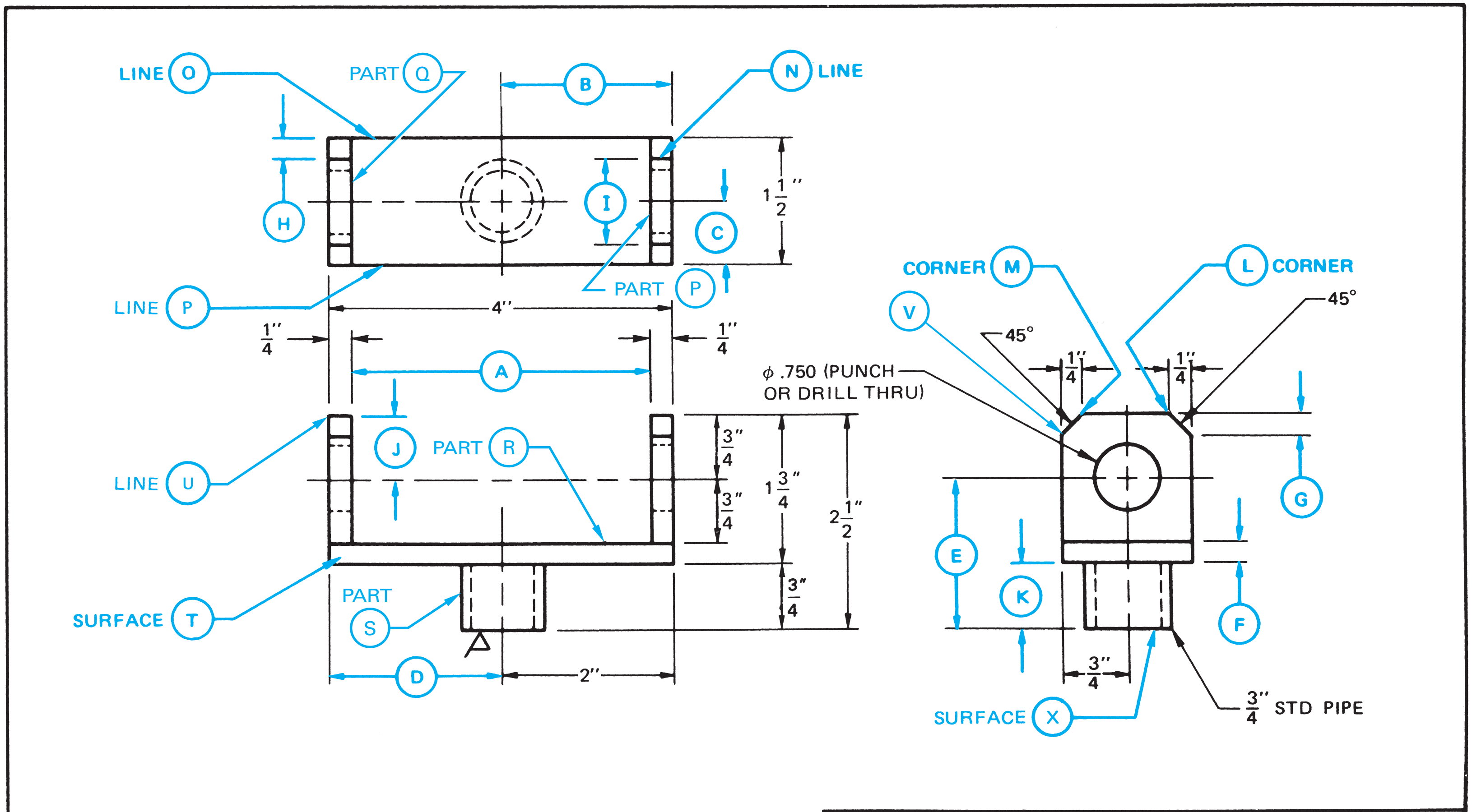
S =

W =

H =

HP =

NOTES



PLATFORM BRACKET HOLDER

QTY 100	ORDER NO. 1082	MATL. CRS PLATE
SCALE 1/2″ = 1″	SPEC	
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 111276	TOLERANCE $+\sim\frac{1}{32}$, ∠±5°	

COMPANY NAME

UNIT 6: REVIEW B

Refer to the drawing, Platform Bracket Holder, page 72.

1. a. Give the dimensions for distances Ⓐ through Ⓚ.

Ⓐ __________ Ⓖ __________

Ⓑ __________ Ⓗ __________

Ⓒ __________ Ⓘ __________

Ⓓ __________ Ⓙ __________

Ⓔ __________ Ⓚ __________

Ⓕ __________

b. If dimension Ⓓ was shown, what kind of a dimension would it be identified as?

____

2. a. What is the angle of the chamfer on the corners of the upright plates?

____

b. What is the angle tolerance?

____

3. What kind of plate is used?

____

4. a. To what diameter does the pipe size refer?

____

b. What is the actual size of the outside diameter?

____

(Refer to the tables in Appendix 3.)

5. What line in the top view represents surface Ⓣ?

____

____

6. a. How many pieces of material are required for fabrication of the part?

____

b. Prepare a bill of materials for the fabrication of the number required for completion of the order.

Bill of Materials

No.	Material	Size

7. What corner in the side view represents line Ⓝ?

____

8. How many holes are there in the completed part, not counting the pipe hole?

____

9. What size are these holes and how are they made?

____

10. What are the overall dimensions for parts Ⓠ, Ⓡ, and Ⓢ? List thickness, width, and length of each part.

Ⓠ __________

Ⓡ __________

Ⓢ __________

11. What part of the holder assembly uses hidden lines in all three views to indicate a portion of its structure?

____

____

____

12. Which surface is specified to have a machine finish?

____

13. What fractional tolerance is specified?

____

14. What angular tolerance is specified?

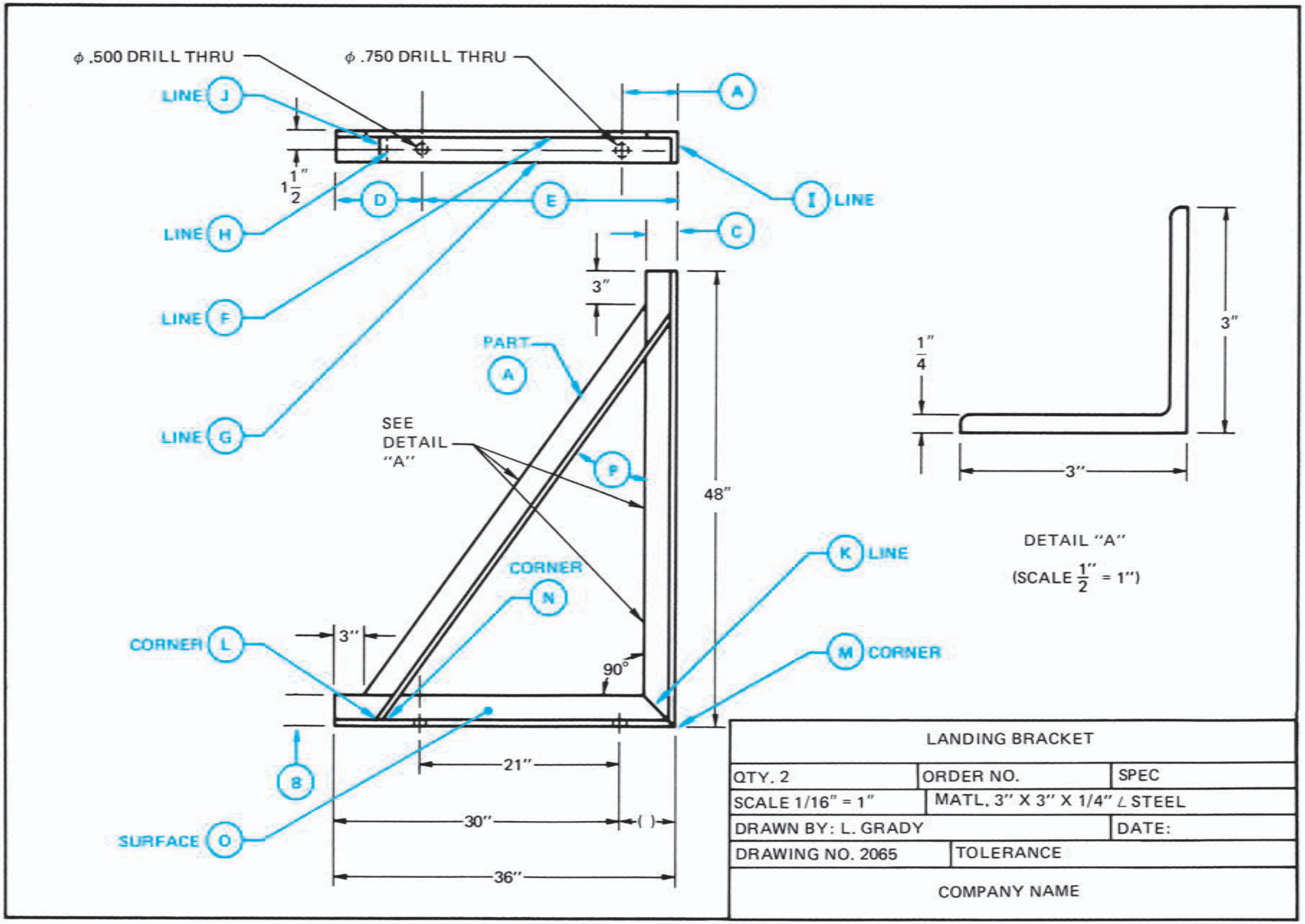
____

15. What line in the front view represents corner Ⓥ?

____

16. What type of drawing is used?

____



LANDING BRACKET

QTY. 2	ORDER NO.	SPEC
SCALE 1/16" = 1"	MATL. 3" X 3" X 1/4" ∠ STEEL	
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 2065	TOLERANCE	

COMPANY NAME

UNIT 6: REVIEW C

Refer to the drawing, Landing Bracket, page 74.

1. What size and type of material is used for all pieces?

____

____

____

2. What scale sizes are used on this print?

____

3. At what angle is line Ⓚ to the vertical leg?

____

4. What line in the top view represents corner Ⓜ?

____

5. What line in the top view represents corner Ⓝ?

____

6. What line in the top view represents surface Ⓞ?

____

7. How many holes are there in the part?

____

8. What sizes are these holes?

____

9. What are the dimensions of distances Ⓐ through Ⓔ?

Ⓐ ______________________________

Ⓑ ______________________________

Ⓒ ______________________________

Ⓓ ______________________________

Ⓔ ______________________________

10. What is the largest dimension shown on the drawing?

____

11. What is the term applied to that part of the structural metal shape indicated by line Ⓕ?

____

12. Determine what angle is represented by Ⓟ. (Use a protractor to determine this answer.)

____

13. Considering the scale size used (excluding detail drawing) indicate the distances representing the following dimensions:

21" ______________________________

30" ______________________________

36" ______________________________

6'6" ______________________________

7'3" ______________________________

14. Insert the missing reference dimension on the drawing. (Examine the views to determine where the reference dimension is required.)

____

____

15. a. Identify the location dimensions for the ∅ .750 hole:

____

b. ∅ .500 hole:

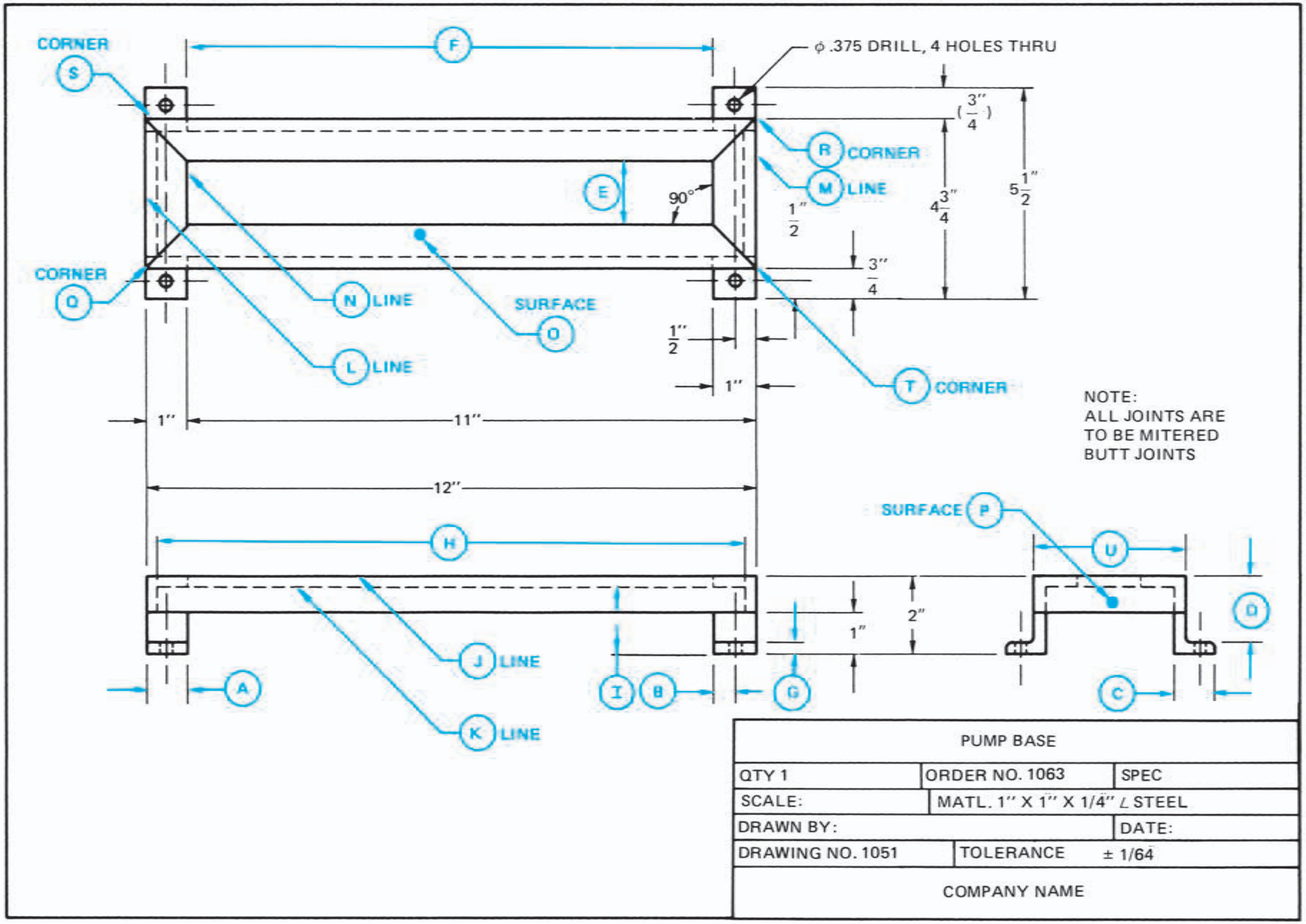
____

16. What is the overall length of the ∠ steel required to fabricate the bracket? Assume part Ⓐ is 56″ long and allow ⅛″ for each cut to be made from a single piece of angle.

____

17. How many brackets are required?

____



NOTE:
ALL JOINTS ARE
TO BE MITERED
BUTT JOINTS

PUMP BASE		
QTY 1	ORDER NO. 1063	SPEC
SCALE:	MATL. 1″ X 1″ X 1/4″ ∠ STEEL	
DRAWN BY:		DATE:
DRAWING NO. 1051	TOLERANCE ± 1/64	
COMPANY NAME		

UNIT 6: REVIEW D

Refer to the drawing, Pump Base, page 76.

1. List the types of lines found on the print.

2. List an item on the print that is considered to be a specification.

3. a. What size holes are required?

   b. How many holes are required?

4. What are the location dimensions for the holes?

5. Identify a dimension that would be classified as a reference dimension.

6. What is the angle represented by the oblique (slanted) lines?

7. What type of joint is shown by the angular lines?

8. What are the dimensions for distances Ⓐ through Ⓘ?

Ⓐ ____________
Ⓑ ____________
Ⓒ ____________
Ⓓ ____________
Ⓔ ____________
Ⓕ ____________
Ⓖ ____________
Ⓗ ____________
Ⓘ ____________

9. What line in the top view represents surface Ⓟ?

10. What line in the front view represents surface Ⓞ?

11. Is distance Ⓐ the same as distance Ⓒ?

12. Make a complete list of materials required for the fabrication of the part.

Bill of Materials

No.	Material	Size

13. The squareness of a rectangular part can be checked by measuring the diagonal distance of the corners. What is the distance from corner Ⓢ to corner Ⓣ and from corner Ⓠ to corner Ⓡ?

14. What is the range of sizes for the 11" dimension?

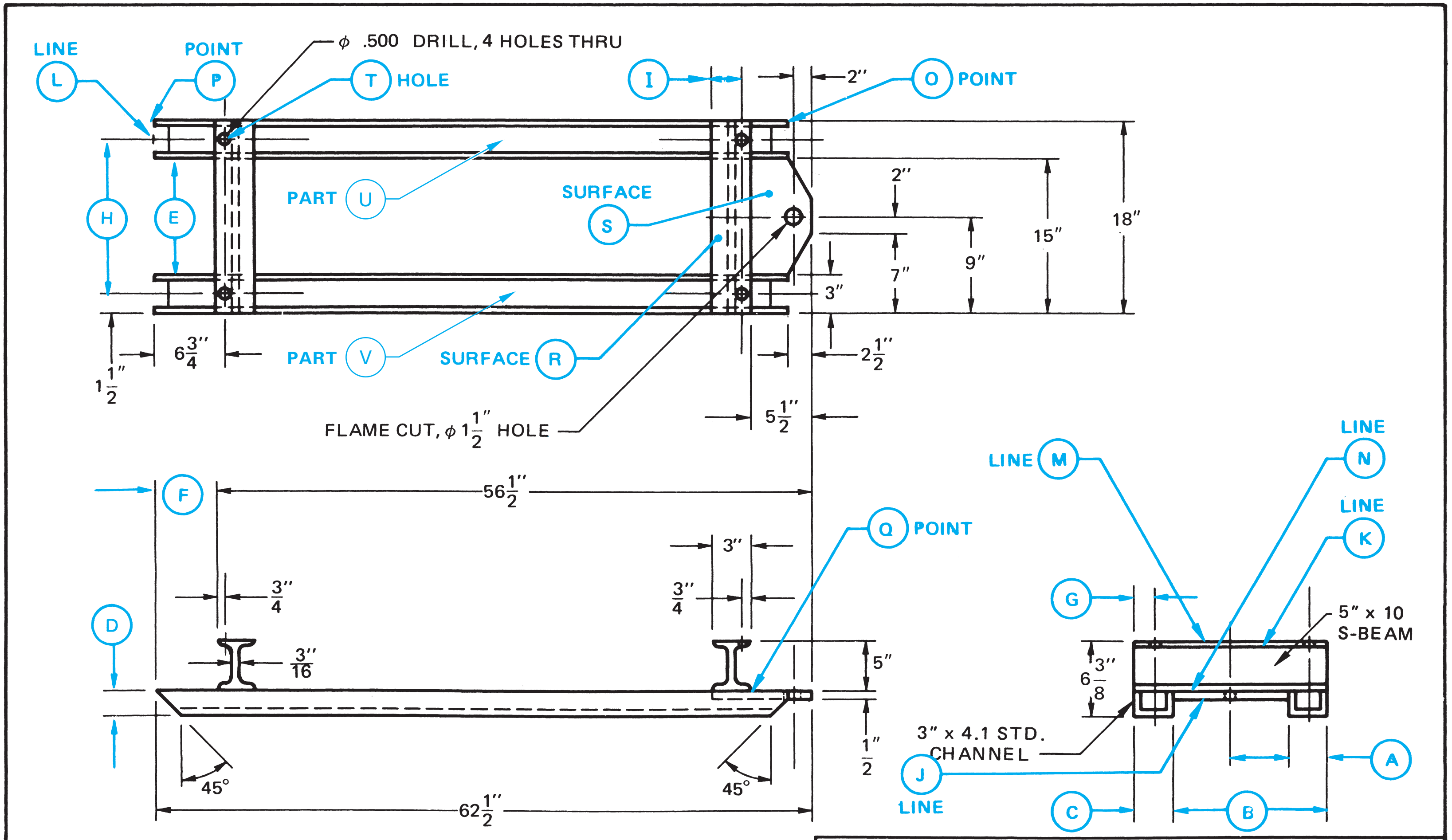
    Max. ____________

    Min. ____________

15. What is dimension Ⓤ?

16. How many pieces are required to make the pump base?

17. What is the total length of ∠ material required?



SKID TYPE ENGINE BASE		
QTY 4	ORDER NO. B401	SPEC
SCALE: 1/16" = 1"	MATL. STEEL-ALL PARTS	
DRAWN BY: L. GRADY	DATE:	
DRAWING NO. 1253	TOLERANCE + 1/16	
COMPANY NAME		

UNIT 6: REVIEW E

Refer to the drawing, Skid Type Engine Base, page 78.

1. What scale size is used on the print?

2. List the structural shapes needed to make the object.

3. Give the dimensions for the distances Ⓐ through Ⓘ.

Ⓐ ________ Ⓕ ________
Ⓑ ________ Ⓖ ________
Ⓒ ________ Ⓗ ________
Ⓓ ________ Ⓘ ________
Ⓔ ________

4. What is the distance from the center of hole Ⓣ to line Ⓛ?

5. What is the distance from point Ⓞ to point Ⓟ?

6. What line in the side view represents surface Ⓡ?

7. What line in the side view represents the underside of surface Ⓢ?

8. What line in the side view represents point Ⓠ?

9. What type and size of material is used for parts Ⓤ and Ⓥ?

10. What is the flange dimension for the S-beam?

11. What is the depth dimension for the S-beam?

12. What is the web size of the S-beam?

13. Give the weight specification applied to the S-beam. Give a reason for including this specification and interpret its significance.

14. List any dimensions not shown that could be used to specify the size of the channel.

15. What is the channel flange width dimension? (Refer to the appropriate table in Appendix 2.)

16. Write the size specifications for the channel pieces according to an accepted form.

17. a. How many holes are required?

    b. Describe the holes required.

    c. Give the location dimensions for the largest hole.

18. Make a complete list of materials needed to fabricate the unit, including overall sizes. Allow +⅛″ for cutting and finishing on overall dimensions.

Bill of Materials

No.	Material	Size

UNIT 7

Other Views

VIEWS WITH CONVENTIONAL BREAKS

Many of the structural shapes to be drawn are too long to be shown on a print in their true size. In addition, the use of a reduced scale size would be impractical because it would be difficult to show fine details. However, this could be overcome by showing an enlarged detail.

If the metal has a uniform structural shape throughout its length, a reduced length can be shown by means of a conventional break symbol. A **break symbol** indicates that a section of the metal has been removed. Figure 7.1 shows the conventional break symbols commonly used on prints. The **location** where the metal has been removed is indicated by break lines. The **amount** removed is not given since it has no significance in the reading of the print. Figure 7.2 shows the break symbol in use on a drawing to reduce the amount of space required to show the object. Note that the part is dimensioned as if the entire part were shown.

Dimensions given on views that have a conventional break are the true sizes, as shown in Figure 7.2.

The shape of an object can be shown by the use of the break symbol. If appropriate section lining is used, the composition of the material can also be indicated. For example, in Figure 7.1 the conventional break symbol that illustrates a rectangular section shows the shape of the section between the break lines. This method of showing the shape in section is often used for structural shapes such as channels, S-beams, and T-shapes. The cross section shown for each shape is called a **revolved section**, Figure 7.3. Note in Figure 7.3 that the section lines indicate the composition of the structural shape. Revolved sections will be discussed in greater detail in Unit 8.

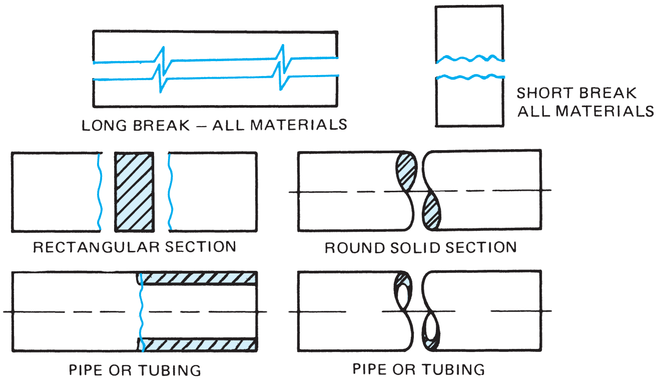


FIGURE 7.1 ■ Typical conventional break symbols.

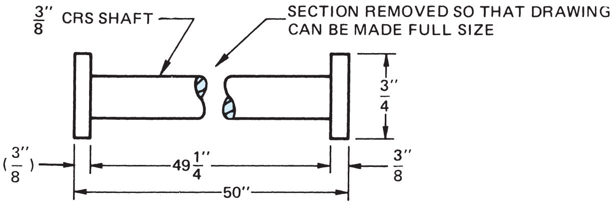


FIGURE 7.2 ■ Dimensioning with a break symbol.

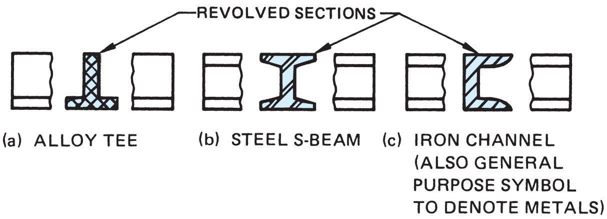

REVOLVED SECTIONS
(a) ALLOY TEE
(b) STEEL S-BEAM
(c) IRON CHANNEL (ALSO GENERAL PURPOSE SYMBOL TO DENOTE METALS)

FIGURE 7.3 ■ Section lining denoting kind of material.

AUXILIARY VIEWS

The preceding units showed that six basic views can be used to represent an object: front, top, right side, left side, bottom, and back. The proper selection and arrangement of several of these views are usually sufficient to represent an object. However, when an object has a slanted (oblique) face, an **auxiliary** view may be included on the print to show the plane of the slanted surface more clearly.

The auxiliary view represents a view of the slanted surface from a position at right angles (90°, perpendicular) to it, Figure 7.4. The surface represented in this manner is shown in its true size and shape. In any other view, this surface is distorted or foreshortened.

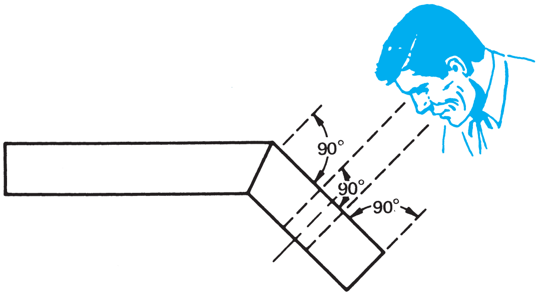


FIGURE 7.4 ■ Position for viewing an auxiliary view.

The development of the auxiliary view is sometimes shown by lines projected perpendicularly from the slanted surface. Usually, only that part of the view that represents the slanted surface is shown, Figure 7.5. A short break line indicates the extent of the view. Dimensions are applied to auxiliary views in the same manner as for other views.

The number of auxiliary views required depends on the number of slanted surfaces an object has. For example, Figure 7.6 shows the auxiliary views used to show the true shape of each of the two oblique surfaces of an object.

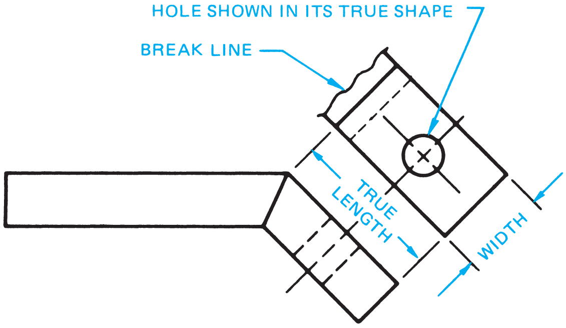


FIGURE 7.5 ■ Auxiliary view as a partial view.

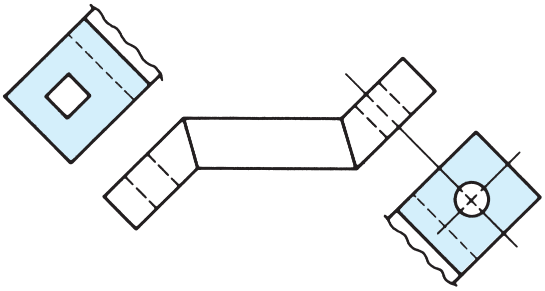


FIGURE 7.6 ■ Multiple auxiliary views.

USE OF BOTH RIGHT SIDE AND LEFT SIDE VIEWS

In general, only a right or left side, top, and front views are required to show clearly all details needed to fabricate a part. However, when the part is very detailed, both right and left side views are shown in addition to the top and front views of the part.

When both side views are included on a print, they are invariably shown as partial views; that is, whatever details are shown in the right side view are not shown in the left side view, and vice versa. Presentation of the details in this manner makes reading the print much easier.

Figure 7.7 illustrates the use of two side views and a front view. Note the detail that is eliminated from one side when shown in the other side view.

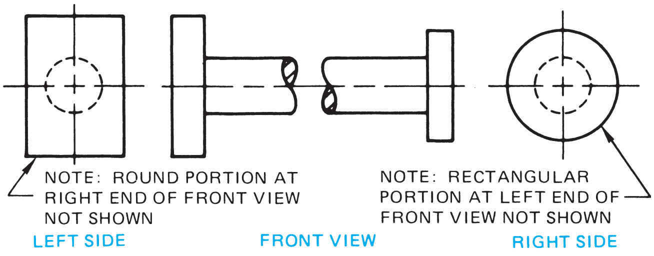

NOTE: ROUND PORTION AT RIGHT END OF FRONT VIEW NOT SHOWN
NOTE: RECTANGULAR PORTION AT LEFT END OF FRONT VIEW NOT SHOWN
LEFT SIDE
FRONT VIEW
RIGHT SIDE

FIGURE 7.7 ■ Use of both side views.

ALTERNATE POSITIONS OF SIDE VIEW

As stated in Unit 1, the side view is normally found adjacent to the front view. However, when this location is not possible due to limited space, the side view is placed next to and in line with the top view. As a result, the space needed to show the three views is reduced, Figure 7.8. Note also that the side view can be placed to the left of either the front view or the top view.

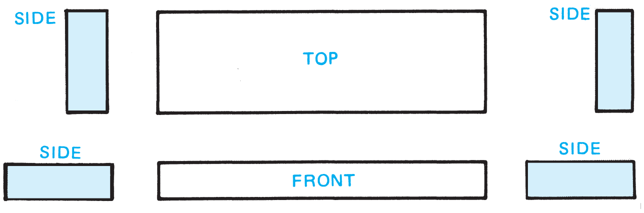


FIGURE 7.8 ■ Alternate positions of side view.

ENLARGED DETAIL VIEWS

While prints may be drawn to a reduced, full, or enlarged scale size, parts are often shown in an enlarged scale. The enlarged portion of the part, also called the **enlarged detail**, is shown as an additional view usually located near the principal view to which it applies, Figure 7.9. The enlarged detail provides more space in which to apply dimensions and makes it easier to interpret the details of the area shown. Each enlarged detail is identified by a letter or number. The same letter or number is also used to identify the point on a principal view to which the detail refers.

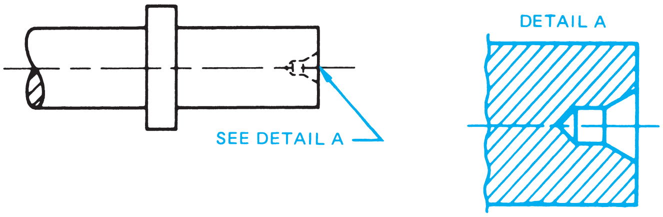
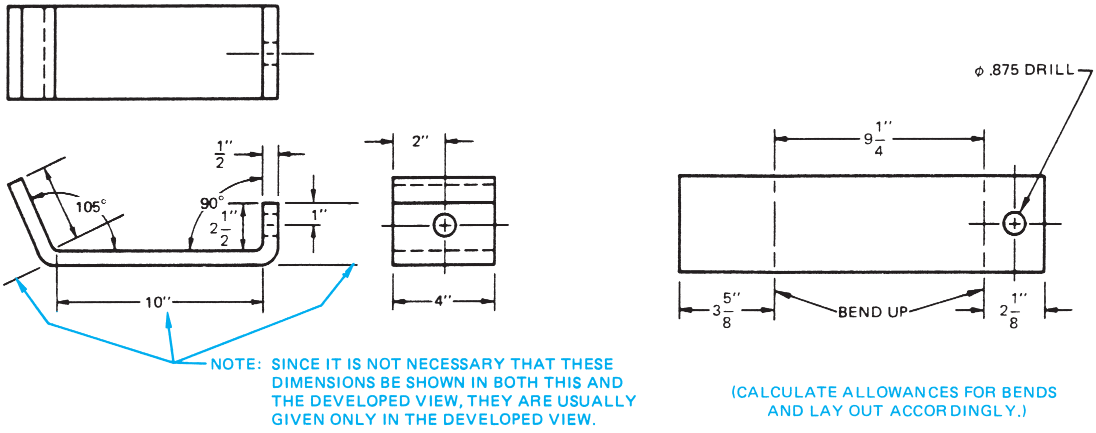


FIGURE 7.9 ■ Enlarged detail of a portion of a part.

DEVELOPED VIEWS

A **developed view**, also called a development, is a view of a part as it appears when stretched or laid out on a flat surface. This view shows the part before it is shaped by bending, rolling, or other fabrication methods. A developed view illustrates the part exactly as it must be prepared before any bending or rolling is performed, Figure 7.10. It may be very simple and involve only one bend, or it may be quite complicated and contain a series of bends, curves, and angles. It is common practice to show the location of any bends on the developed view. In addition, dimensions shown on the developed view include any allowances necessary for bending or rolling.



NOTE: SINCE IT IS NOT NECESSARY THAT THESE DIMENSIONS BE SHOWN IN BOTH THIS AND THE DEVELOPED VIEW, THEY ARE USUALLY GIVEN ONLY IN THE DEVELOPED VIEW.

(CALCULATE ALLOWANCES FOR BENDS AND LAY OUT ACCORDINGLY.)

THREE VIEWS AS THEY APPEAR ON DRAWING.

DEVELOPED VIEW AS IT APPEARS ON DRAWING.

NOTE: WHEN MATERIAL IS BENT, AN ALLOWANCE MUST BE MADE IN THE DEVELOPMENT FOR THE STRETCHING OF THE MATERIAL. IN GENERAL, EACH INDUSTRY WILL DEVELOP ITS OWN METHOD OF DETERMINING BEND ALLOWANCES AND WILL SET UP FORMULAS TO COMPUTE ALLOWANCES BASED ON THE ANGLE OF THE BEND AND THE THICKNESS OF THE MATERIAL.

A COMMONLY USED GUIDE FOR DETERMINING THE BEND ALLOWANCES OF MATERIAL IS AS FOLLOWS: THE SUM OF THE INSIDE DIMENSIONS OF THE FINISHED PIECE + 1/3 THE THICKNESS OF SOFT MATERIALS FOR EACH BEND, OR + 1/2 THE THICKNESS OF HARD MATERIALS FOR EACH BEND.

FIGURE 7.10 ■ The developed view.

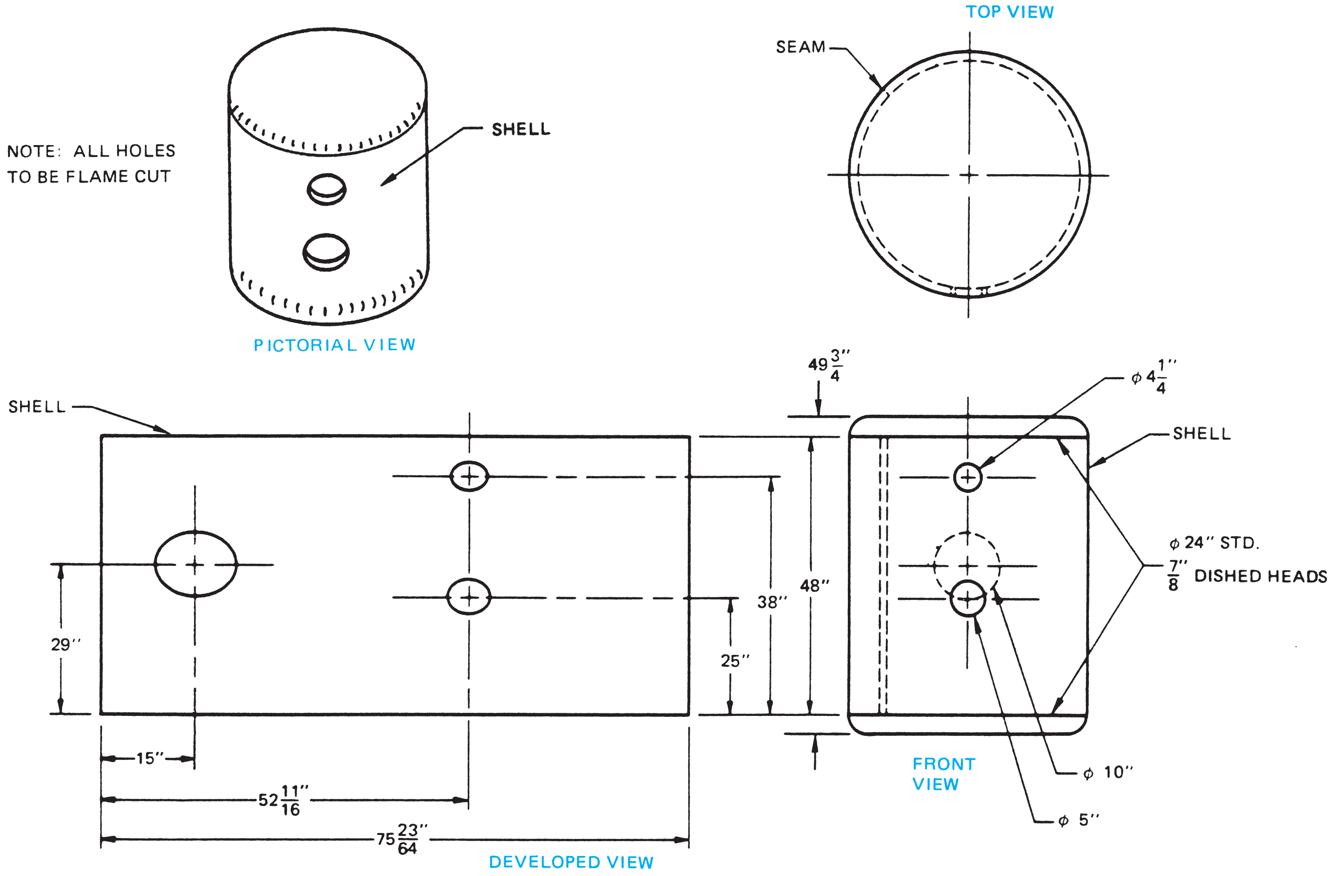


FIGURE 7.11 ■ Drawing of a tank including the developed view of the shell.

A developed view is also used to indicate the locations of holes in sheets or plates that are to be rolled or shaped into cylindrical forms, Figure 7.11. Hole sizes and location dimensions may be given either on the drawing of the part or on the developed view. It is not necessary to give the dimensions on both.

In many cases, a developed view is absolutely necessary. For example, the following shapes all require developed views for fabrication: fabricated angular pipe joints in which the sections are rolled from sheet or plate, and fabricated spheres, curved domes, or heads, Figure 7.12 and Figure 7.13. Note in Figure 7.12 that the dimensions added to the developed views follow the baseline system of dimensioning.

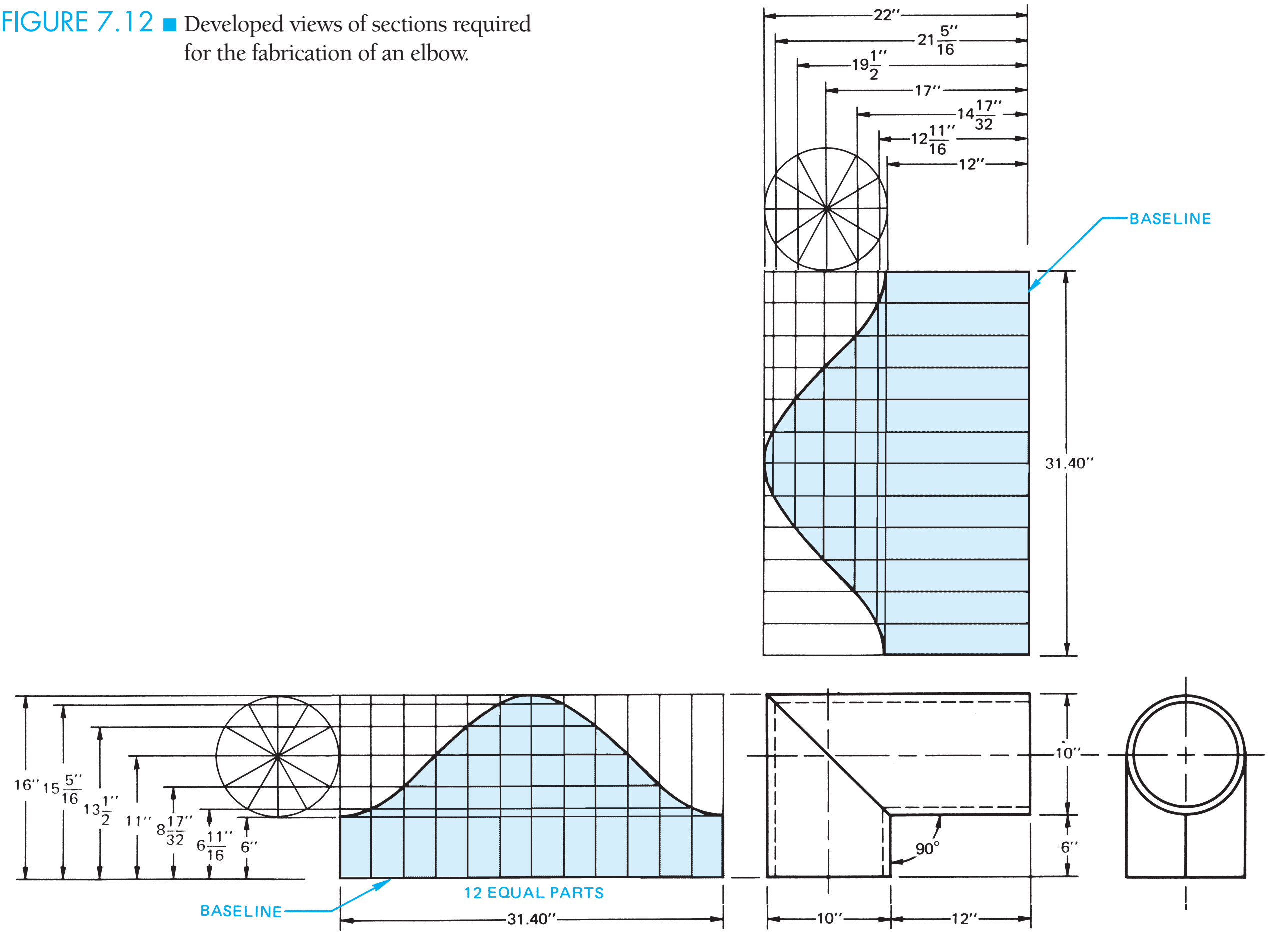
NOTE:

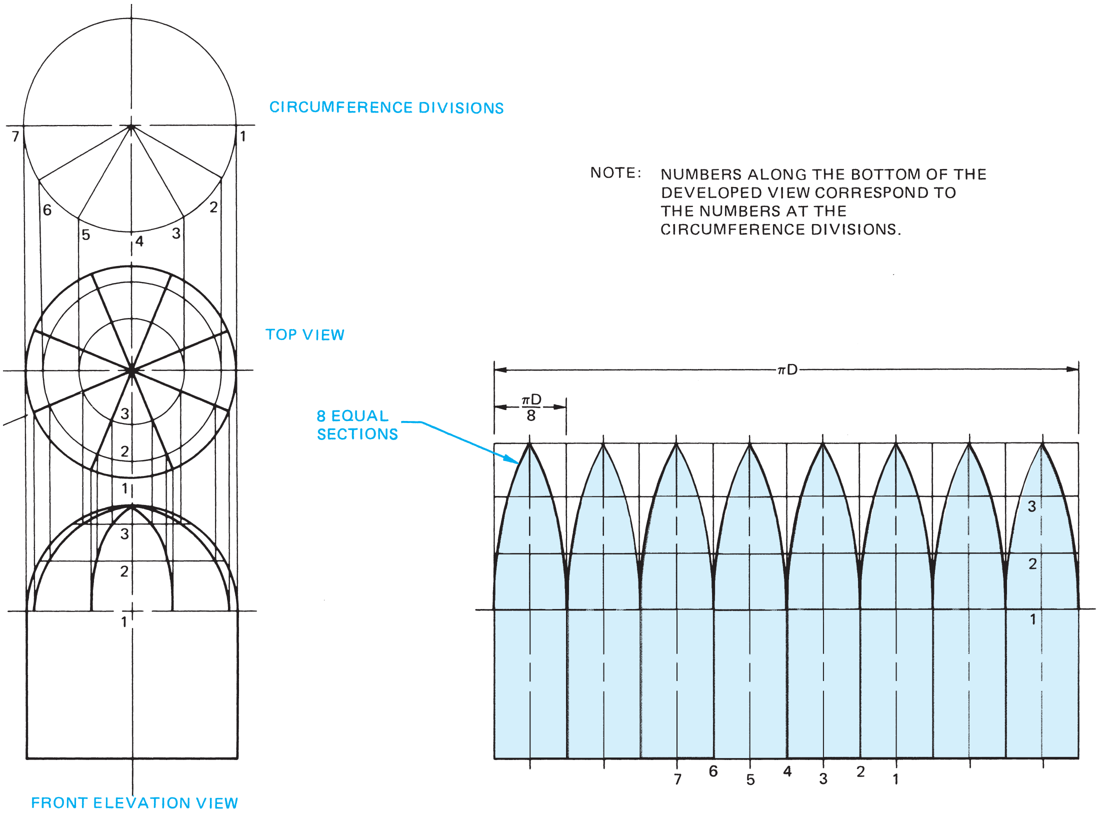
FORMULA FOR STRETCH OUT
3.14 (Pi) or π
$\underline{\times 10\text{" (Dia.)}}$
31.40" S.O. (Stretch Out)

REVOLVED VIEWS

When an object is shown in true projection, it is drawn in all views as it actually appears. However, in some cases, one view of the object may be shown as it does not actually appear. For example, in a revolved view, a portion of the object is rotated in order to obtain a straight axis, Figure 7.14(b). In this position, the true shape of the object can be determined. This is done to give a more complete description of the object and to make the drawing easier to read. Although this is considered a violation of true projection, it is nevertheless preferred as shown in Figure 7.14.

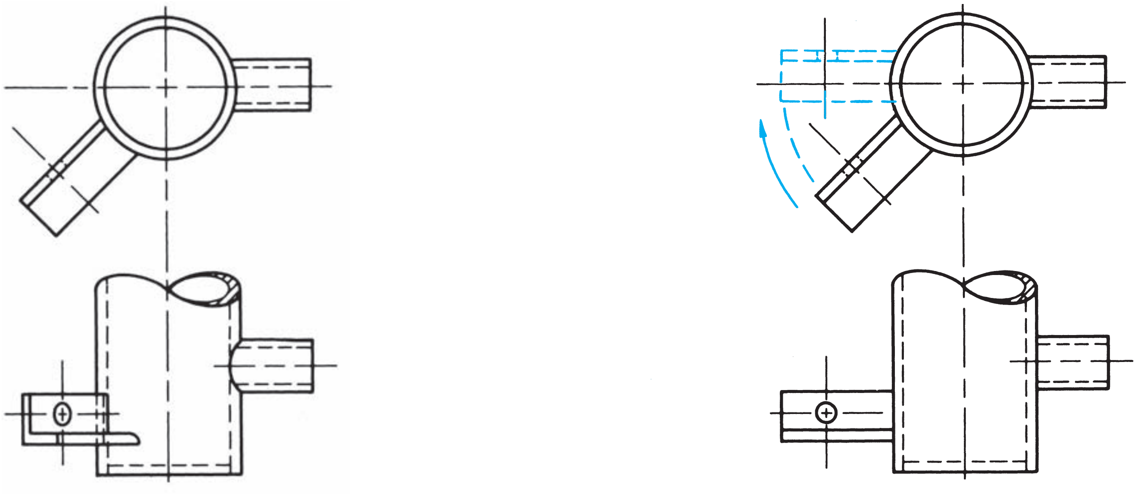
FIGURE 7.12 ■ Developed views of sections required for the fabrication of an elbow.





NOTE: NUMBERS ALONG THE BOTTOM OF THE DEVELOPED VIEW CORRESPOND TO THE NUMBERS AT THE CIRCUMFERENCE DIVISIONS.

FIGURE 7.13 ■ Developed view at right showing layout of plates for dome-shaped head.



(a) TRUE PROJECTION

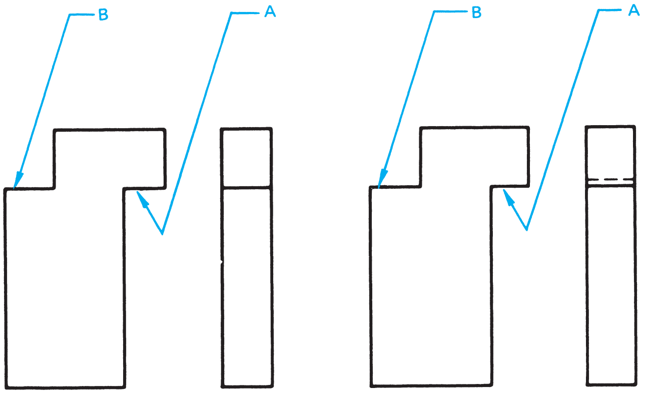
(b) ROTATED METHOD OF PROJECTION (Preferred)

FIGURE 7.14(a, b) ■ Revolved projection.

NOTE: In Figure 7.14(a), there is considerable detail shown where the angle iron and the small pipe join the larger pipe. Also, the hole in the angle iron is not shown in its true shape. In Figure 7.14(b), there is much less detail where the parts are joined and the hole is shown in its true shape, thus simplifying interpretation of the lower view.

UNTRUE PROJECTION

It is possible that lines representing two different surfaces of an object shown in one view would, when shown in another view, appear as one line. This tends to make the drawing confusing and more difficult to read. Therefore, one of these lines may be shown out of true projection in order to show the edges of the two different surfaces, as illustrated in Figure 7.15.



(a) TRUE PROJECTION

(b) UNTRUE PROJECTION

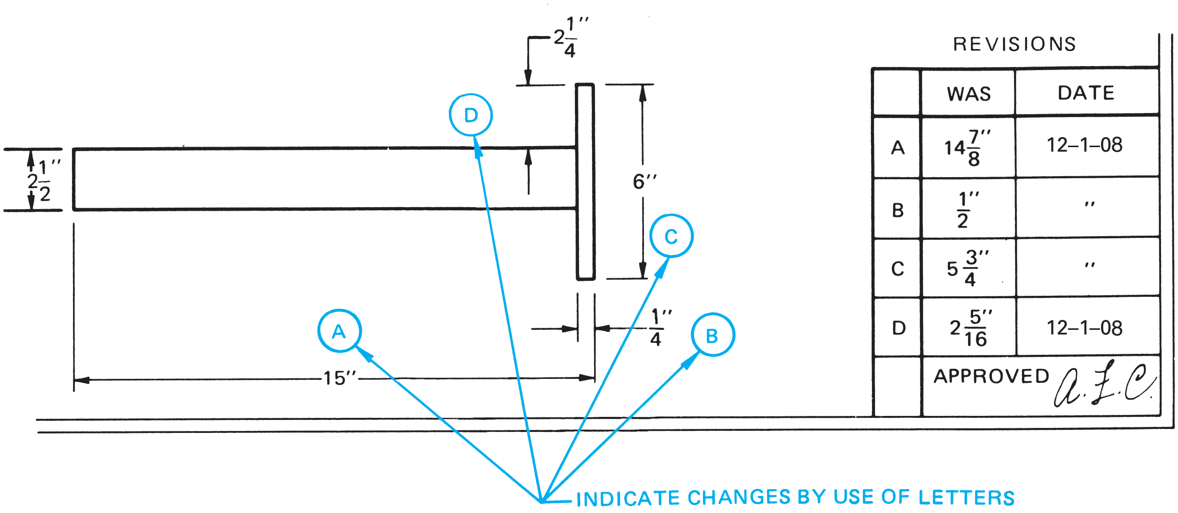
NOTE: A and B in Figure 7-15(a) are represented in the right side view by the same line. In Figure 7-15(b), A and B are represented by two lines. Although this is considered a violation, it is nevertheless used occasionally.

FIGURE 7.15 ■ Using untrue projection.

CORRECTIONS AND REVISIONS ON PRINTS

When an error is discovered on a drawing while in use in the shop, quite often the error will be marked with a red or yellow pencil. Any such error is usually reported to the supervisor so that corrections can be made on future drawings or on the master drawing of the print being used.

When revisions are required due to changes in design, they are often made on the original copy from which the blueprint was made. In some cases, the original size dimension will be removed and the new one substituted. When such a procedure is followed, a listing of the original sizes will usually be made on the drawing, as shown in Figure 7.16.



REVISIONS

	WAS	DATE
A	$14\frac{7}{8}''$	12–1–08
B	$\frac{1}{2}''$	″
C	$5\frac{3}{4}''$	″
D	$2\frac{5}{16}''$	12–1–08
	APPROVED a.f.c.	

FIGURE 7.16 ■ Making corrections.

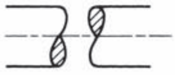
UNIT 7: REVIEW A

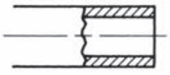
Graph paper is provided at the end of this review for your use.

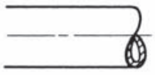
1. Give three reasons for showing a conventional break on a print.

2. Illustrate by a simple sketch one method that can be used to show a revolved section of a length of channel. Use graph paper provided.

3. a. What do the symbols illustrated indicate?





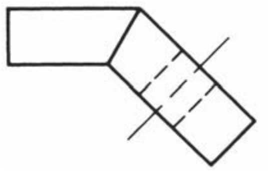


   b. What material is represented?

4. a. When is an auxiliary view used to show a part?

   b. Is an auxiliary view dimensioned?

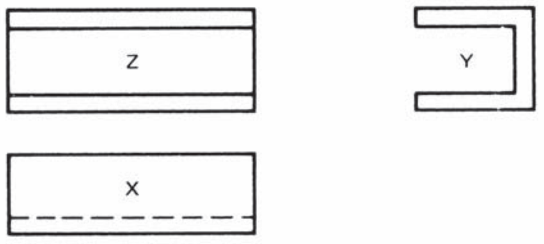
5. Develop an auxiliary view from the sketch shown. Assume that the part is ¾″ wide.



6. a. When two side views are used, describe where they may be located with respect to the front and top views.

   b. Show this as a simple illustration on the graph paper provided.

7. Sketch two other arrangements of the views represented by the following orthographic sketch.



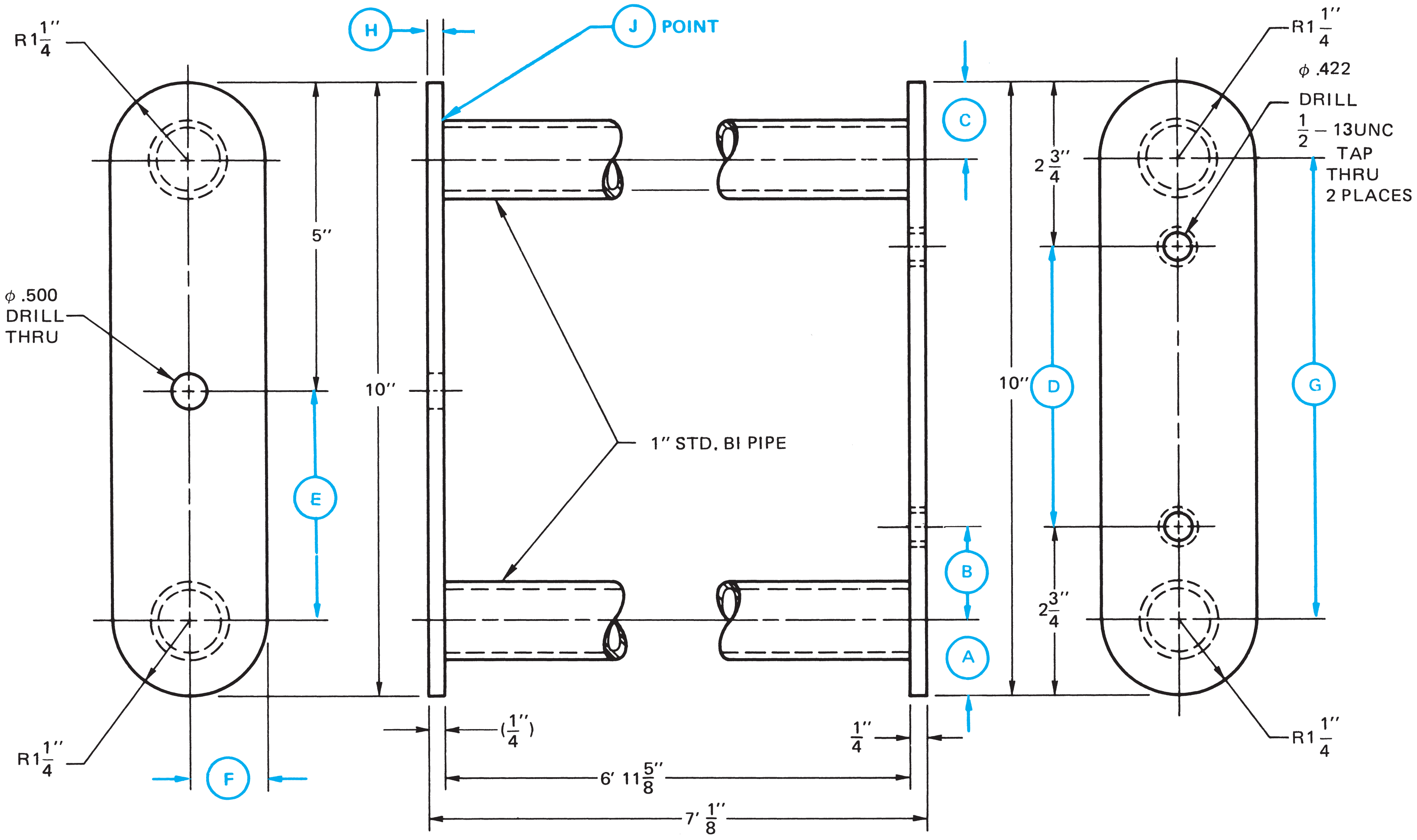
8. Give two reasons for showing an enlarged detail on a print.

9. What linear distances would be shown on a drawing if the following dimensions are drawn to the scale sizes indicated?

	Dimension	**Scale Size**	**Distance**
a.	2″	2″ = 1″	
b.	4″	¾″ = 1″	
c.	¾″	2″ = 1″	
d.	1⅝″	3″ = 1″	
e.	5⁄32″	3″ = 1″	
f.	17⁄64″	2″ = 1″	

10. Prepare a simple one-view sketch to show the use of a long break line.

NOTES



NOTE: TOLERANCES ON HOLES ± .005"
OTHER THAN HOLES TO BE TAPPED.
TOLERANCES ON FRACTIONAL
DIMENSIONS ± $\frac{1}{16}$" EXCEPT FOR STANDARD
MAT. SIZES.

ORNAMENTAL SUPPORT POST		
QTY 1	ORDER NO. 789	MATL. CRS
SCALE 3/8" = 1"	SPEC	
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 7082	TOLERANCE	
COMPANY NAME		

UNIT 7: REVIEW B

Refer to the drawing, Ornamental Support Post, page 92.

1. What is the difference between the right and left side views?

2. Interpret the significance of ½ – 12 UNC.

   ½ ____________________

   12 ____________________

   UNC ____________________

3. What structural shape is indicated by the conventional break symbol?

4. What is the significance of the following symbol: ⌖?

5. What are the dimensions for distances Ⓐ through Ⓗ?

   Ⓐ ____________ Ⓔ ____________

   Ⓑ ____________ Ⓕ ____________

   Ⓒ ____________ Ⓖ ____________

   Ⓓ ____________ Ⓗ ____________

6. What are the largest and smallest sizes permissible for the ∅ .500 hole?

   Maximum ____________________

   Minimum ____________________

7. What size drill should be used for the tapped hole?

8. What is the maximum permissible overall length of the assembly?

9. Do any of the tolerances given apply to the tapped hole? Give a reason for your answer.

10. Using the scale size given on the print, determine the lengths of the following dimensions:

    5" ____________ 1¼" ____________

    2¾" ____________ ½" ____________

11. On what parts are conventional break symbols used?

12. Why is a conventional break symbol used on the drawing of the ornamental support post?

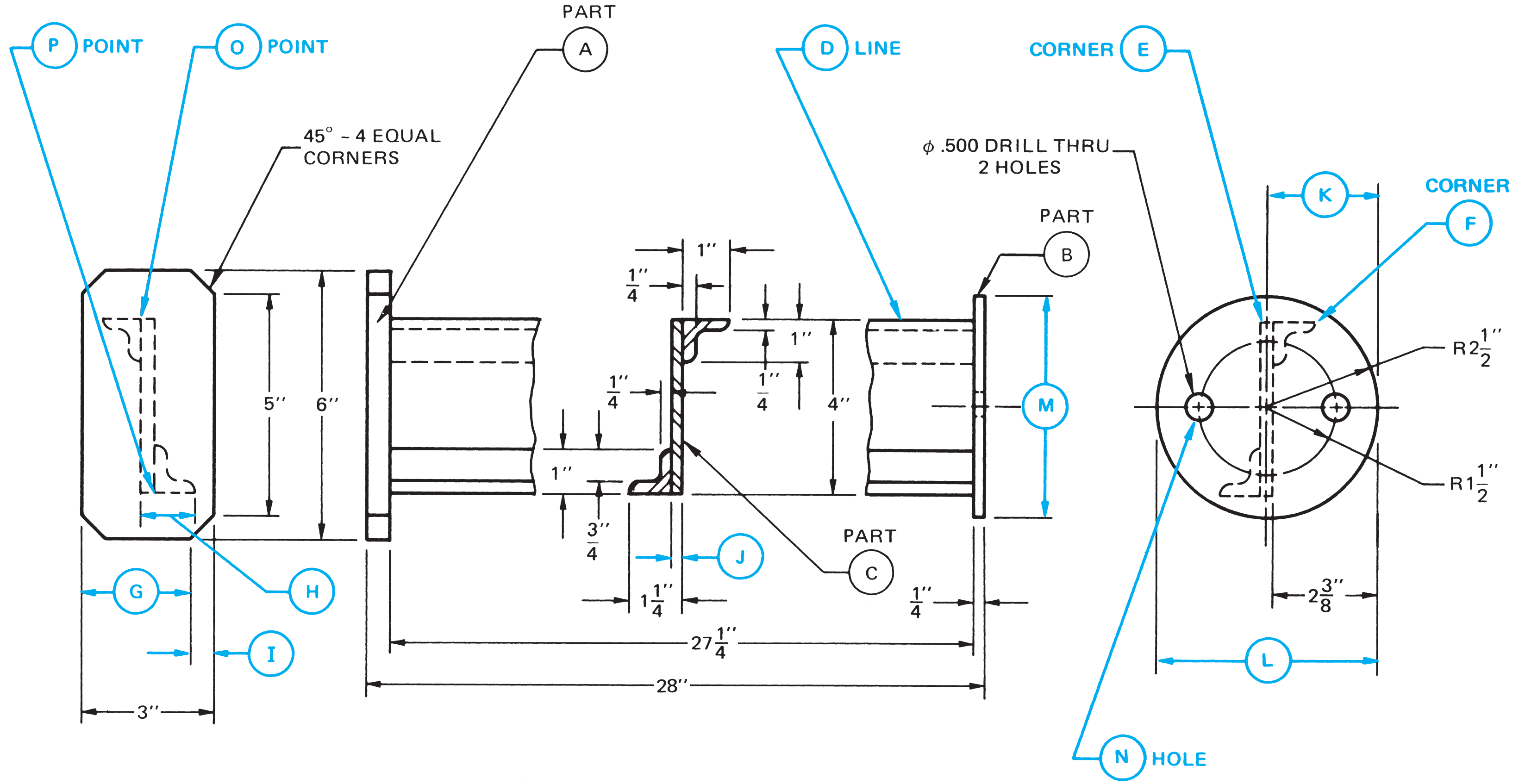
13. Identify which dimension on the drawing is a reference dimension.

14. a. What nominal size pipe is used?

    b. What is the inside diameter ∅ of the pipe? (Refer to Appendix 3.)

    c. What material is the pipe?

    d. On the print, indicate locations where welds could be applied.



TOLERANCES ON ALL DRILLED HOLES ± .005''

TOLERANCES ON ANGULAR DIMENSIONS ± .5°

TOLERANCES ON ALL OTHER DIMENSIONS ± 1/64''

SUPPORT ARM

QTY 2 | ORDER NO. 86B | MATL LOW CARBON STEEL

SCALE 1/4'' = 1'' | SPEC

DRAWN BY: L. GRADY | DATE:

DRAWING NO. 1150 | TOLERANCE ∠2°

COMPANY NAME

UNIT 7: REVIEW C

Refer to the drawing, Support Arm, page 94.

1. Name the views that are used to show the part.

   ____

   ____

2. Which two views are shown as partial or incomplete views?

   ____

   ____

3. Why are two of the views shown as partial views?

   ____

   ____

4. What is the purpose of using a conventional break line on the drawing?

   ____

   ____

5. What type of view is shown between the break lines?

   ____

   ____

6. At what angle are the corners of part Ⓐ to be chamfered?

   ____

7. What is the largest angle at which the corners of part Ⓐ can be chamfered?

   ____

8. What are the overall dimensions for the pieces that make up part Ⓒ?

   ____

   ____

9. What corners represent line Ⓓ?

   ____

10. What are the dimensions for distances Ⓖ through Ⓜ?

    Ⓖ ________ Ⓙ ________ Ⓛ ________
    Ⓗ ________ Ⓚ ________ Ⓜ ________
    Ⓘ ________

11. How many holes are there in the object?

    ____

12. What is the largest size that these holes can be made?

    ____

13. What is the smallest size that these holes can be made?

    ____

14. At what angle are the holes spaced from one another?

    ____

15. What is the lateral center-to-center distance of the holes?

    ____

16. a. What is the minimum size that the following dimensions can be made: ¼″, 27½″, 2⅜″?

    ¼″ ________ 27½″ ________ 2⅜″ ________

    b. What is the decimal equivalent for these dimensions?

    ¼″ ________ 27½″ ________ 2⅜″ ________

17. a. What structural shapes are used for the parts shown in the view between the break lines?

    ____

    b. Refer to the section lines and identify the kind of material that is to be used.

    ____

18. Make a complete bill of materials required for completion of the part. Allow ¼″ for finishing. Assume that the same kind of material is used throughout.

Bill of Materials

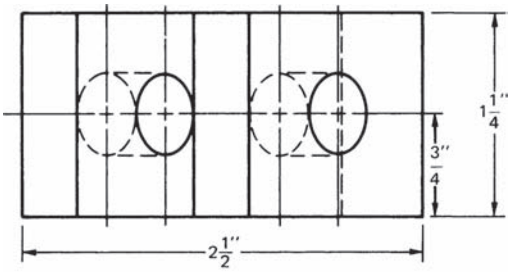
No.	Material	Size

19. What part is shown as a revolved section?

    ____

UNIT 7: REVIEW D

1. Sketch the development drawing required for making the pats as illustrated by the two views that follow. Use the graph paper provided to sketch your answer.



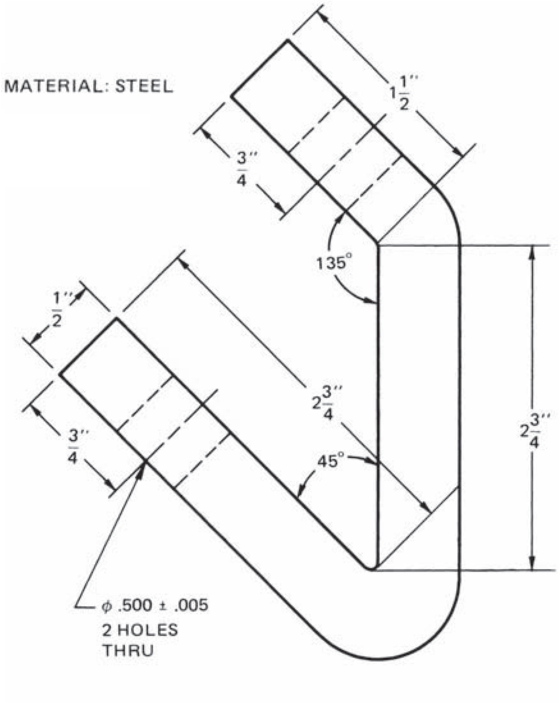
NOTE: TOLERANCE ON ANGULAR DIMENSIONS ± 2°

2. a. What is the maximum size permitted for the drilled holes?

   b. What is the minimum size permitted for the drilled holes?

3. What is the maximum angle of bend for the 45° dimension?

4. What is the thickness and kind of material required?



MATERIAL: STEEL

ϕ .500 ± .005
2 HOLES
THRU

5. What is the overall length of the material required?

UNIT 7: REVIEW E

1. Give a brief explanation as to what is meant by true projection.

2. Why, in some cases, is it necessary to show a part of the drawing as an untrue projection?

3. Is it considered a violation of true projection when a revolved projection is used?

4. a. Give a formula that can be applied for determining the bend allowance for a soft material.

   b. For a hard material.

UNIT 8

Sections

FULL SECTIONS

A full section (or cross section) is a view of an object which is **imagined** to be cut entirely in half, with half of the object then removed so that the cut surface can be viewed for its details. However, the imagined removed part is not left out of the other views.

The cut surface is represented by section lines. Different materials can be represented by various arrangements of these lines but, for the most part, regular section lining is used and a note is added to specify the material.

The extent of the cut surface, also called the **cutting plane**, is shown by a cutting plane line located on one of the principal views. This line indicates the direction from which the principal view is to be viewed to derive the section. In addition, the line indicates where the section is located with relation to the principal view. Note that the cutting plane line is composed of long dashes alternating with a pair of short dashes.

Figure 8.1 illustrates a full section using regular section lining. Note the position and extent of the section in relation to the cutting plane line.

A print may show several different sections of the same part when one section does not adequately show the interior details. However, the sections shown may not be full sections, but rather may be sections that represent only portions of the part. How these sections are derived is indicated by as many cutting plane lines as there are sections needed to show the interior of the part. Each section is identified by pairs of letters that are the same as those located near the points of the cutting plane line.

Figure 8.2 illustrates two full sections of a part. Note how each section is identified with relation to the cutting plane line. Section lines are shown only where the imaginary cut has passed through the material. Their arrangement shows that the part is made from one piece of material. It is preferred practice not to show broken lines on section drawings. However, they are sometimes included to help interpret the shape of the part.

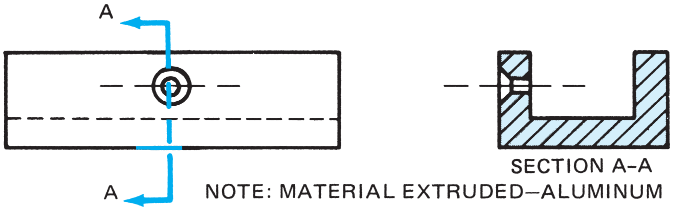


FIGURE 8.1 ■ Front view and full section.

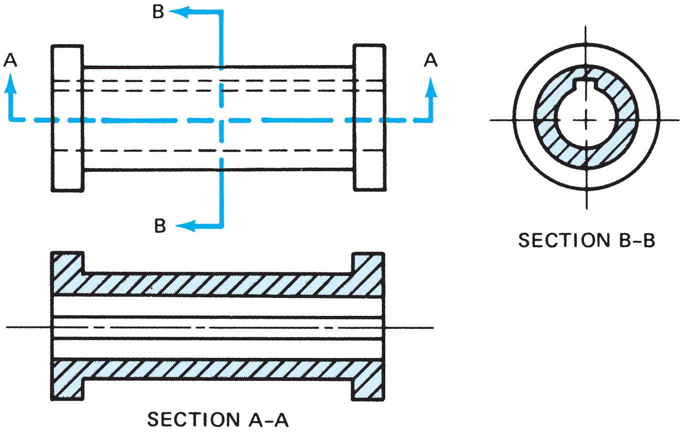


FIGURE 8.2 ■ Front view with two full sections.

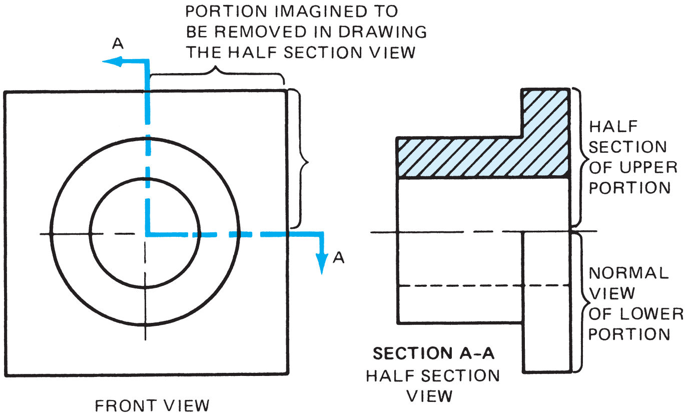


FIGURE 8.3 ■ Front view and half section view.

HALF SECTIONS

A **half section** is a view of an object which is **imagined** to be cut only halfway through (a one-quarter section of the part, Figure 8.3). The cut portion is then removed so that the details of the cut surface can be viewed. The view of the cut surface shows one half as a section and the other half as it normally appears in a principal view. Half sections are used primarily to show the interior construction details of symmetrical parts.

Section lines are used to indicate the imaginary cut surface of a half section in the same manner as for full sections. The cutting plane lines serve the same function as those used for full sections, but differ as shown in Figure 8.3. Note the difference in the way a half section is represented as compared to a full section.

REVOLVED SECTIONS

The cross section (true shape) of a structural metal shape is often shown on a view by a revolved section. As the name implies, a revolved section of a shape is a cross section that has been turned (revolved) 90°.

When the metal is of such a shape and length that break lines are not necessary, the revolved section appears as a view placed on top of another, Figure 8.4.

A revolved section can be placed in a space between break lines when break lines are used to indicate a reduced length. A revolved section may also be shown in a space between break lines when the structural shape is not uniform in size, Figure 8.5. In this case, break lines are not necessarily used to signify a reduced length, but may be used to indicate where the revolved section applies.

Although it is not always necessary to include a revolved section, it is often shown to aid print interpretation.

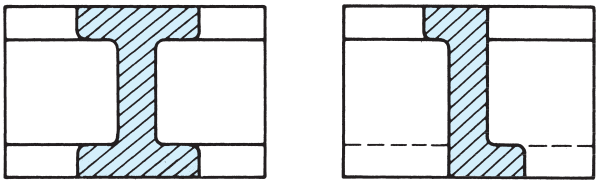


FIGURE 8.4 ■ Revolved section.

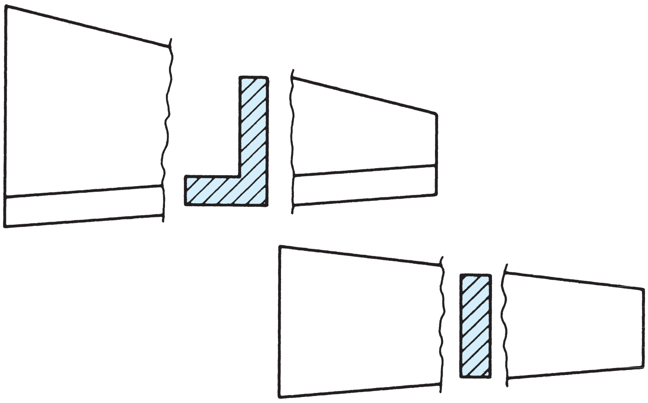


FIGURE 8.5 ■ Revolved sections applied for regular but nonuniform structural shapes.

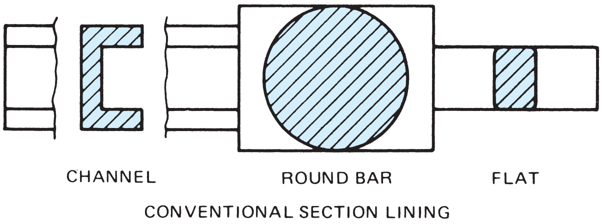


FIGURE 8.6 ■ Application of revolved sections.

When a structural member of a weldment has several different cross-sectional shapes, these shapes can be shown on a print by as many revolved sections as are needed to describe the object. Figure 8.6 illustrates several revolved sections for a single structural member.

ASSEMBLY SECTIONS

An **assembly section** is achieved in the same manner as a full section or half section. However, in this case, the interior details of assembled parts are represented.

The section lines used in assembly sections are shown running in different directions so that one part can be differentiated from another.

Surfaces of thin materials shown in section are not indicated by section lines; rather, they are shown as solid black lines. When several thin materials are shown adjoining one another, a thin space is allowed between the solid lines to show their separation.

Figure 8.7 illustrates a section of an assembled part. Note the difference in the directions of the section lining.

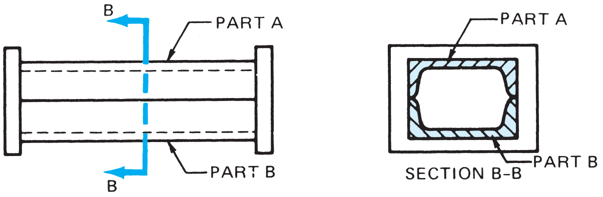


FIGURE 8.7 ■ Assembly section.

PHANTOM SECTIONS

A **phantom section** is a view primarily used to show a mating part. The phantom section may or may not be shown in detail on the drawing. Its primary purpose is to show how the parts fit or operate together, Figure 8.8. A phantom section may also be used to illustrate the function of the object. This type of section is not dimensioned or shown in great detail. The shape (perimeter) of the phantom object and its alternate positions are shown through the use of short, thin dashed lines (-----).

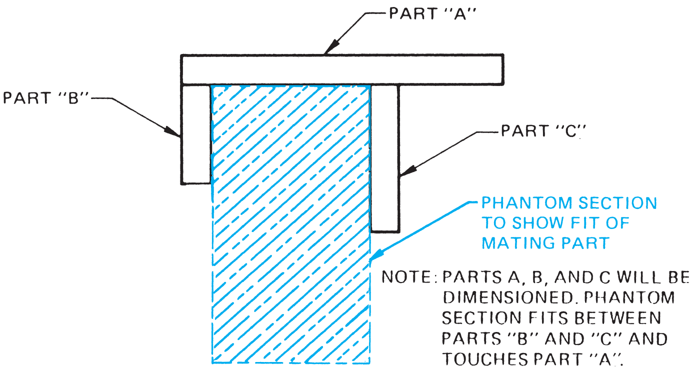
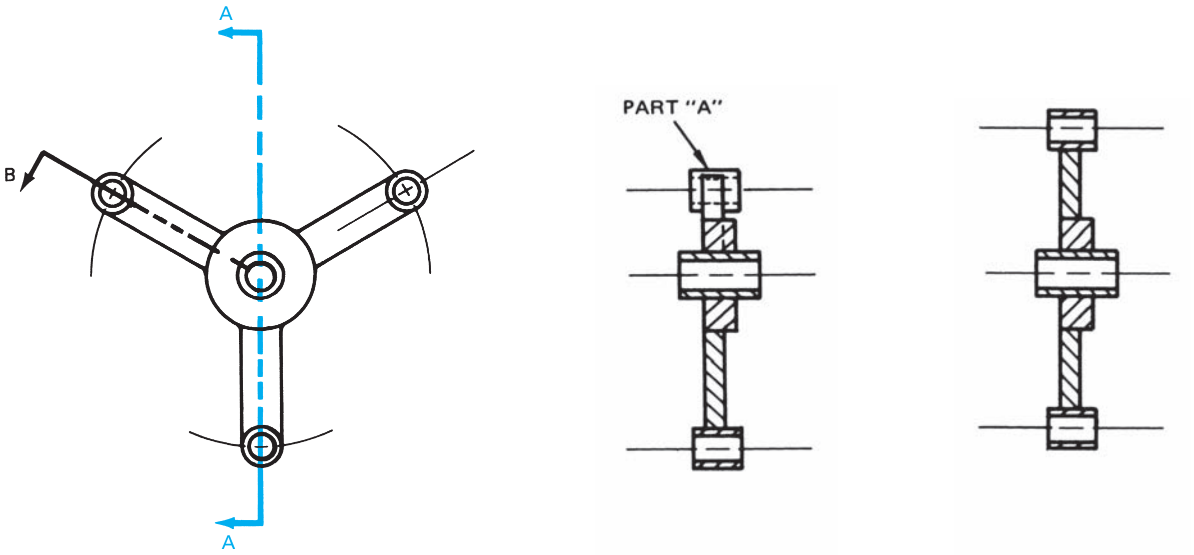

PART "A"
PART "B"
PART "C"
PHANTOM SECTION TO SHOW FIT OF MATING PART
NOTE: PARTS A, B, AND C WILL BE DIMENSIONED. PHANTOM SECTION FITS BETWEEN PARTS "B" AND "C" AND TOUCHES PART "A".

FIGURE 8.8 ■ Phantom section.



(a) TOP VIEW OF PART A

(b) SECTIONAL VIEW THROUGH A–A

(c) ALIGNED SECTION THROUGH A–B

FIGURE 8.9 ■ Aligned sectional view.

ALIGNED SECTIONS

When revolved projection is incorporated within a sectional view it is called an **aligned section.** In this case the cutting plane line is literally bent to include certain features in the part that are best shown as revolved projections.

NOTE: Notice that part A is not completely shown in the sectional view, Figure 8.9(b). Figure 8.9(c) illustrates the preferred aligned section. The advantage of drawing an aligned section becomes apparent in comparing these views.

BROKEN-OUT SECTIONS

A broken-out section, like other sections, is used to show the interior of a part. The extent of the section is shown by a short break line, Figure 8.10.

OTHER SECTIONS

Other types of sections include **offset sections** and **removed sections.** Note that each section receives its name from the method in which it is obtained or shown. A basic knowledge of full and half sections will assist in understanding these other types of sections.

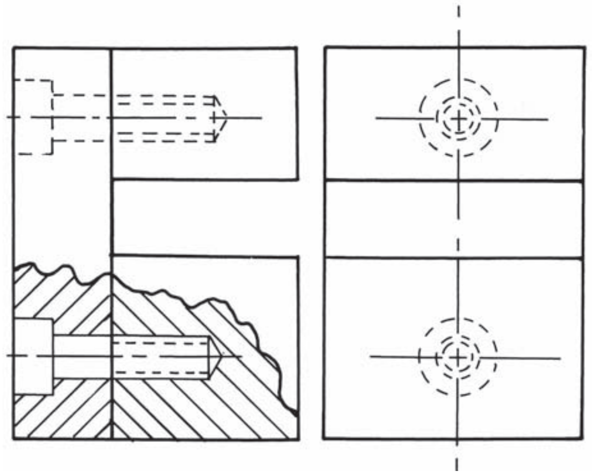
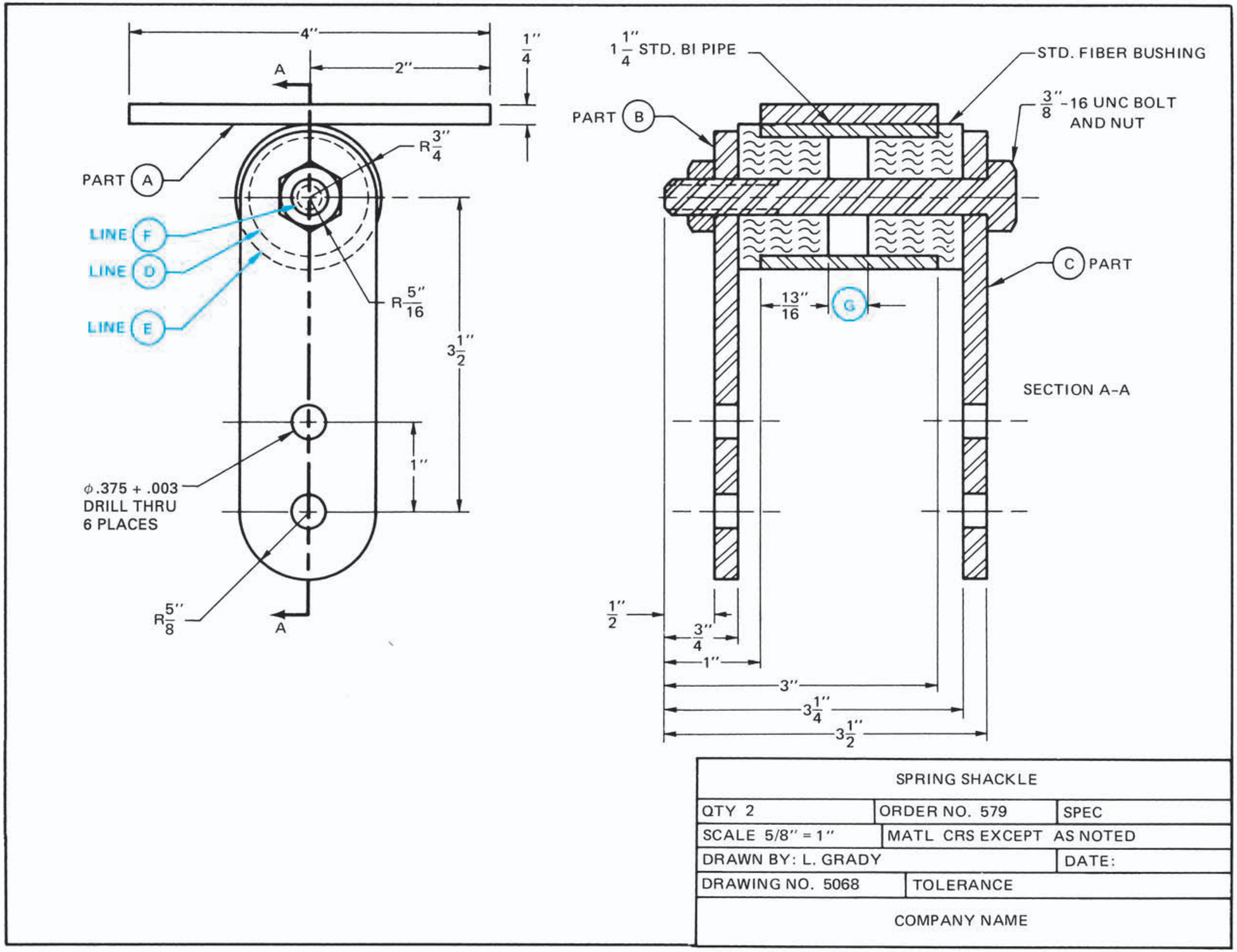


FIGURE 8.10 ■ Broken-out section.

NOTES



SPRING SHACKLE		
QTY 2	ORDER NO. 579	SPEC
SCALE 5/8" = 1"	MATL CRS EXCEPT AS NOTED	
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 5068	TOLERANCE	
COMPANY NAME		

UNIT 8: REVIEW A

Graph paper is provided at the end of this review for your use.
Refer to the drawing, Spring Shackle, page 104.

1. Name the views shown.

2. Identify those parts whose cross-hatching lines indicate the kind of material from which they are made.

3. Which method (or methods) of dimensioning is (are) used on this print?

4. What linear length represents the dimension 3¼″ on this print?

5. List the location dimensions for the ∅ .375 holes.

6. What is the overall size of the rectangular plate?

7. Sketch a symbol used on this print to represent an external thread.

8. Which part or parts does line Ⓔ represent?

9. Which line is used in the view shown to the left to represent the 1¼″ pipe size?

10. Which line represents the outside circumference of the thread?

11. What is the shape of the nut?

12. What is the dimension for distance Ⓖ?

13. Prepare a bill of materials for making this object.

Bill of Materials

No.	Material	Size

14. What is the size of the bolt required?

15. What is the size of the nut across flats?

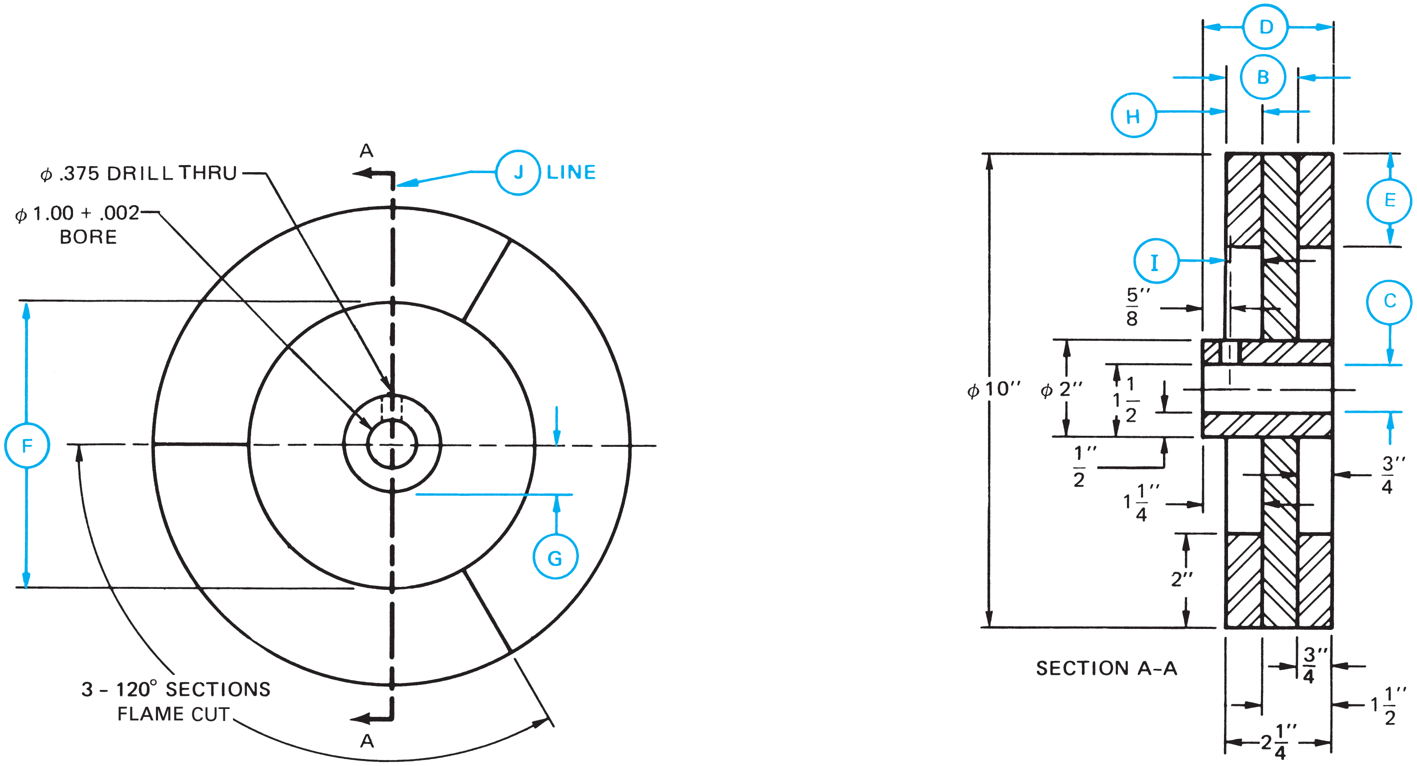
16. What is the tolerance specified for drilled holes?

17. What type of section is shown?

18. Identify the parts to be drilled.

19. What is the OD of the fiber bushing?

20. What is the ID of the BI pipe? (Refer to Appendix 3.)



NOTE: TOLERANCE OF + $\frac{1''}{16}$ ON ALL FLAME CUT PARTS

TOLERANCE ON ALL DRILLED HOLES + .005''
UNLESS OTHERWISE SPECIFIED

TOLERANCE ON ALL FINISH DIMENSIONS ± $\frac{1''}{64}$

TOLERANCE ON ANGULAR DIMENSIONS ± 1°

GEAR BLANK		
QTY 1	ORDER NO. 89	SPEC
SCALE 1/4'' = 1''	MATL COLD ROLLED STEEL	
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 30	TOLERANCE: SEE NOTE	
COMPANY NAME		

UNIT 8: REVIEW B

Refer to the drawing, Gear Blank, on page 108.

1. a. Identify the view shown on the left.

   b. Identify the line on this view that indicates that a section view is required.

2. What type of section view is used?

3. Why is a section view used?

4. a. Why do groups of the section lines shown vary in direction from other groups?

   b. What type of material is represented by the section lines used?

5. What are the dimensions for distances Ⓑ through Ⓘ?

Ⓑ ______ Ⓕ ______

Ⓒ ______ Ⓖ ______

Ⓓ ______ Ⓗ ______

Ⓔ ______ Ⓘ ______

6. Why should the ∅ .375″ hole be drilled before fabricating the part?

7. a. How much oversize can all flame cuts be made?

   b. How many flame cuts are to be made?

8. How much undersize can all flame cuts be made?

9. What are the limits on the finished outside diameter of the part?

10. Make a complete bill of materials required for making the part. Allow limits as indicated on the print for any overall size that may require finishing.

Bill of Materials

No.	Material	Size

11. a. How many sections of the 10″ circular part are required?

    b. What method is specified for cutting these parts?

12. What is the wall thickness of the hub?

13. What is the order number of the part?

14. How many degrees are specified for each of the flame cut sections?

15. a. What method is specified for cutting the 1″ diameter hole?

    b. What is the tolerance for the 1″ diameter hole?

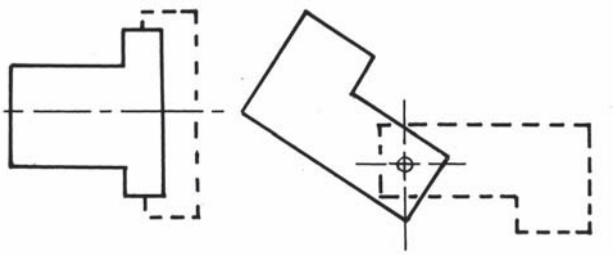
UNIT 8: REVIEW C

1. a. Describe the type of line used for showing the perimeter of a phantom section.

   b. Sketch the type of section lining used to illustrate a part that is drawn in phantom. Show this within a rectangular phantom shape.

2. a. What are two purposes of a phantom section drawing?

   b. Fill in the appropriate portions of the following sketches using phantom section lines to illustrate two purposes for a phantom section drawing. Identify the purpose of each.

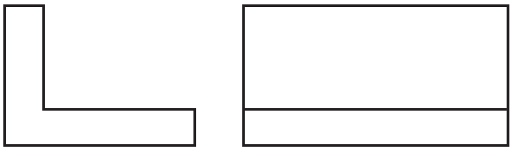


3. a. Is the part that is shown in phantom usually dimensioned?

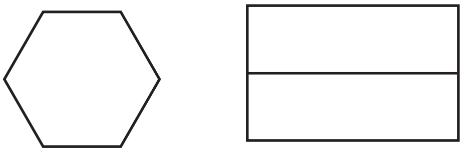
   b. Give an explanation for your answer to 3a.

4. Sketch a revolved section for the following metal shapes and identify each shape. Use graph paper provided for answers.

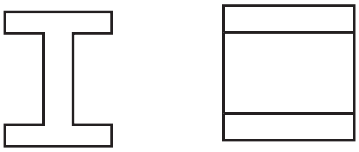
a.



b.



c.



9 UNIT

Detail, Assembly, and Subassembly Prints

DETAIL DRAWING

Components of weldments are shown in detail by prints that are called *detail* or *working prints*. A detail print contains all the information needed to make a part, including the views required for a complete description and the dimensions that are needed for its construction, and may include the directions (indicated by notes and symbols) for the operations required.

It is preferred practice to prepare a detail print for every member of an assembly. However, if the parts are small and similar operations are involved, they are sometimes grouped on one print, Figure 9.1. When a part is a unit within itself, only one print is usually required to describe it.

When a unit consists of several parts, and they are to be shown on one print, each part must be identified. One method of identification commonly used gives each part a name and a circled letter or number. A similar letter or number is given to the part on the assembly print so that the detail can be identified readily with the part shown on the assembly.

Detail prints may include only that information that applies to welding operations, or they may include the information needed for all the operations required to make the part.

In the detail print, Figure 9.1, note the complete dimensioning and how each part is identified.

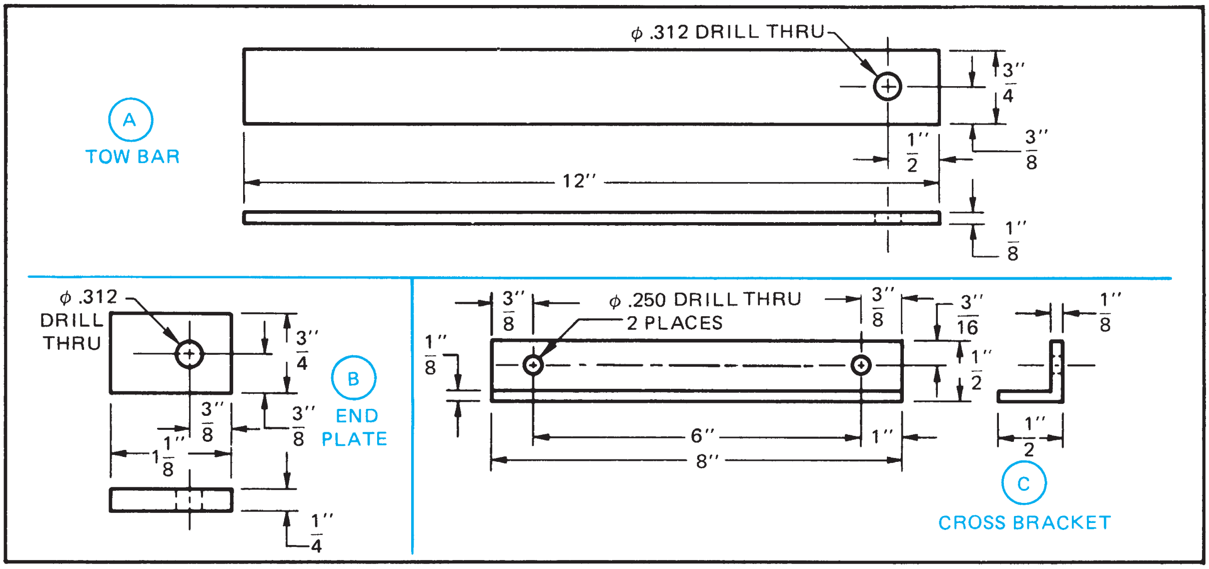


FIGURE 9.1 ■ Multiple-detail print (represents several detail drawings).

ASSEMBLY PRINTS

An **assembly print**, often identified as a main or top assembly, shows the complete and assembled object. This type of print is intended to show the relationship of one part to another when assembled as a unit, and to give an indication of the general appearance of the assembly. Broken lines are usually omitted to simplify reading of the print. This type of print is used as a guide for assembling finished parts.

Certain assembly prints may be used as detail prints when complete dimensions are applied to all of the assembled parts. Prints of this kind are sometimes prepared for comparatively simple weldments; however, this is not a preferred practice.

Assembly prints may consist of one or more views of the assembled unit. Several views are shown when the assembly is complex. More than one print may be used for a complex assembly to show these views. All views are shown by the same scale size throughout except for enlarged detail views.

To show certain portions of the assembly more clearly, enlarged details of parts are drawn to an enlarged scale size, and may be included on the assembly print or as an attachment.

Figure 9.2 illustrates the assembly print of a simple assembly, including several parts shown in the details of Figure 9.1. Note that, in this case, no dimensions are applied. Also, the parts are identified by letters corresponding to those shown on the detail print. Standard hardware used in the assembly is described in the bill of materials (refer to the detail print for the Adjustable Bumper Hitch on the next page). Note that standard hardware items are not usually dimensioned in the detail print. Such items may also be shown in a listing of specifications.

SUBASSEMBLY PRINTS

When an object consists of a number of separate assembled units that comprise the complete assembly, the individual units are often drawn as subassemblies. The main or top assembly is first prepared and the subassemblies are identified on the print by a letter or a number and a name for referencing purposes. A drawing for each subassembly is then prepared, and each is identified by the letter or number and name found on the main assembly. Note that in many cases, subassembly drawings may consist of several views and may be shown in an enlarged detail. These drawings are helpful in the interpretation of prints and the assembly of parts; also, they facilitate the preparation of bills of materials. As a rule, a bill of materials is prepared for each subassembly and shown in a ruled space on the drawing.

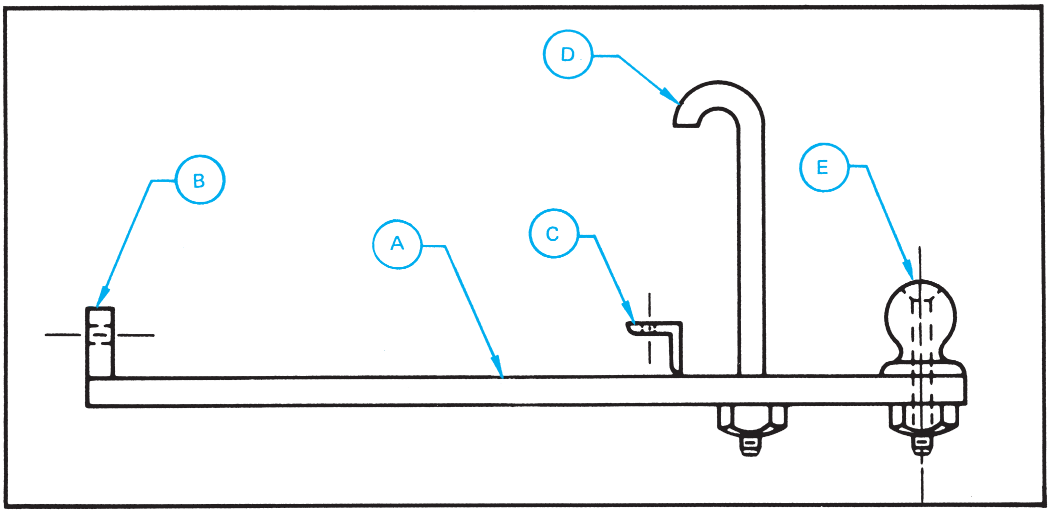
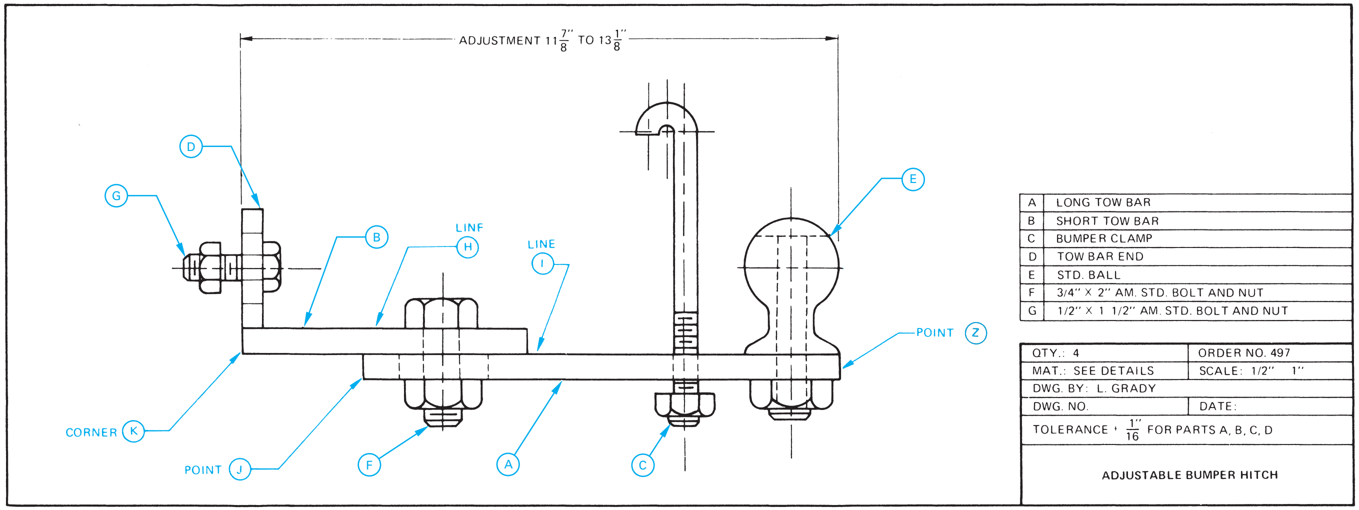
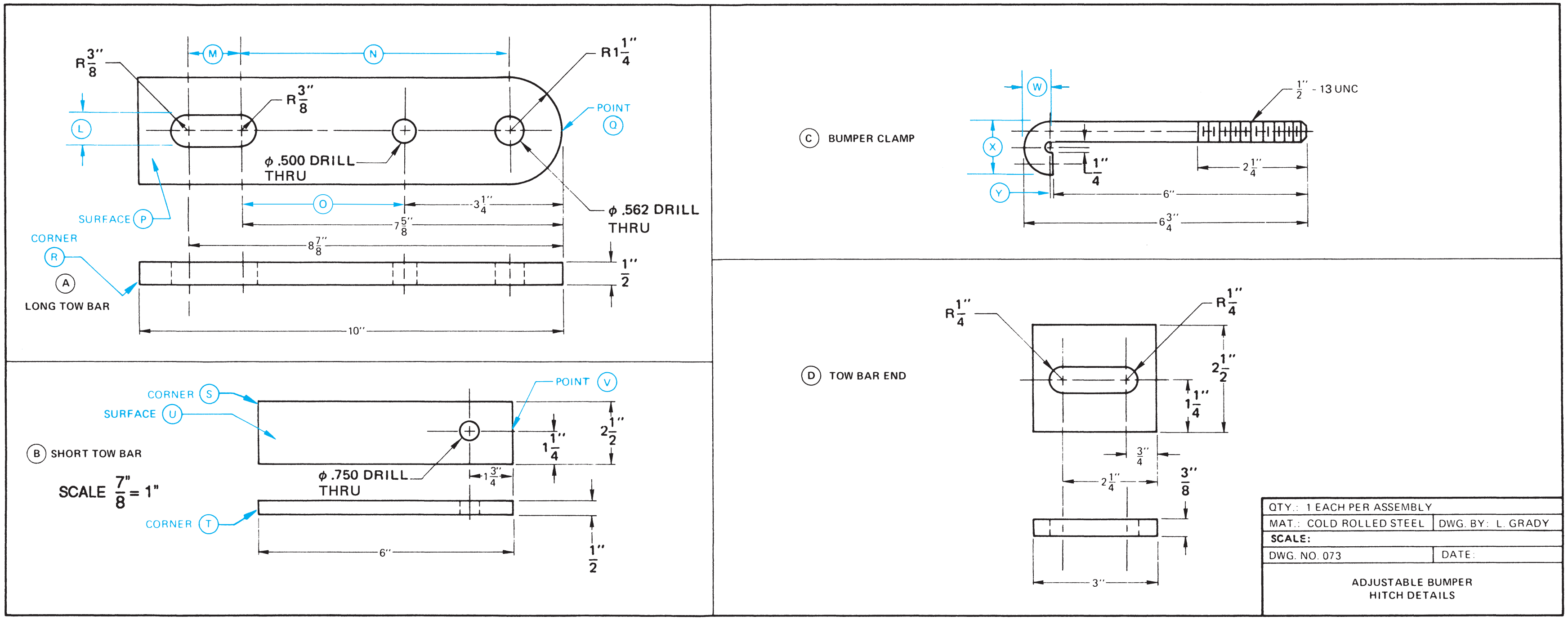


FIGURE 9.2 ■ Assembly print.



DETAIL AND
ASSEMBLY PRINTS
FOR
ADJUSTABLE
BUMPER HITCH



EDITOR'S NOTE: REDUCED PRINT. FOLLOW STATED DIMENSIONS ONLY. NOT TO BE SCALED.

UNIT 9: REVIEW

Refer to the drawing, Adjustable Bumper Hitch Details, page 116.

1. What are the dimensions for distances Ⓛ, Ⓜ, Ⓦ, Ⓧ, Ⓞ, and Ⓨ?

   Ⓛ ____________ Ⓧ ____________
   Ⓜ ____________ Ⓞ ____________
   Ⓦ ____________ Ⓨ ____________

2. Why is it unnecessary to show the details for parts Ⓔ, Ⓕ, and Ⓖ?

   ____

3. What are the maximum lengths of the following dimensions: ⅝″, 8⅞″, and 6¾″?

   ⅝″ ________ 8⅞″ ________ 6¾″ ________

4. Explain the significance of the dimension ½″−13 UNC.

   ____
   ____

5. Give a reason for showing only one assembly view.

   ____
   ____

6. What is the maximum diameter for the bumper clamp thread specification?

   ____

7. Which line in the assembly print represents surface Ⓤ?

   ____

8. Which point in the detail represents point Ⓩ?

   ____

9. Which corner in the detail represents corner Ⓚ?

   ____

10. Which point in the assembly represents corner Ⓡ?

    ____

11. What is the largest overall length to which the hitch may be adjusted?

    ____

12. How many slots will there be in the completed bumper hitch?

    ____

13. How many drilled holes will there be in the completed bumper hitch?

    ____

14. How many inches of thread must be cut to complete the order? Disregard stock items.

    ____

15. Make a complete list of materials that will be required to complete the order. Include overall dimensions.

Bill of Materials

No.	Material	Size

16. From what material are all parts of the assembly to be made?

    ____

17. What does a subassembly print represent?

    ____

18. Give three reasons for preparing a subassembly drawing.

    ____
    ____
    ____

19. List two terms used to identify a complete assembly drawing.

    ____
    ____

20. Give two reasons for preparing an assembly drawing.

    ____
    ____

21. a. After reviewing foldout drawing 9 "Mandrel Puller Ass'y.", list the instructions for its assembly.

    ____
    ____

    b. Interpret the following items found in the assembly instructions:

    1. DR. 7/16 (0.437⌀) THRU (4X) ________
    2. HEX. HD. MACH. SCR. 3/8−16 × 1/2 LG.

       ____

    3. 3/8−16 NUT (4X) ____________

    c. Explain the purpose of the reference dimension(s). ________________________

    ____

22. What is the total number of pieces required to make the Mandrel Pulley?

    ____

23. What is the total weight of the Mandrel Pulley?

    ____

10 UNIT

Welding Symbols and Abbreviations

WELDING SYMBOL

A standard welding symbol and weld symbols have been developed by the American Welding Society (AWS). These symbols developed by the AWS are covered in detail in the units that follow. The standard welding symbol, Figure 10.1, consists of a **reference line**, an **arrow**, and a **tail.** Each component has a particular function. The reference line is used to apply weld symbols and other data, and the arrow connects the reference line to the joint or area to be welded. The tail is added only when needed for the purpose of including a specification process or other reference.

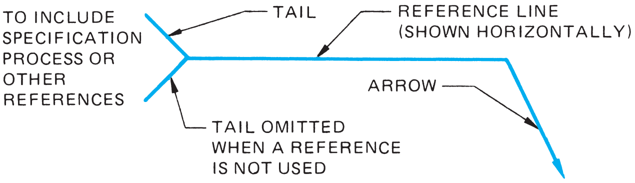

TO INCLUDE SPECIFICATION PROCESS OR OTHER REFERENCES
TAIL
REFERENCE LINE (SHOWN HORIZONTALLY)
ARROW
TAIL OMITTED WHEN A REFERENCE IS NOT USED

FIGURE 10.1 ■ Standard welding symbol.

The phrase **welding symbol** refers to the total symbol including all information added to it to specify the weld(s) required. **Weld symbol,** on the other hand, refers to the symbol for a specific type of weld. The weld symbol is only part of the total information that may be contained in the welding symbol.

The arrow of the welding symbol may be shown with or without a break. When shown with a break, the break is made toward the member of the joint that is to be prepared or shaped, Figure 10.2. Note that if there is no preference as to which joint member is to be prepared, or it is obvious which member is to be prepared, the arrow need not be shown with a break. The arrow is always drawn at an angle to the reference line. It is never drawn parallel (horizontal) to or in the same plane as the reference line.

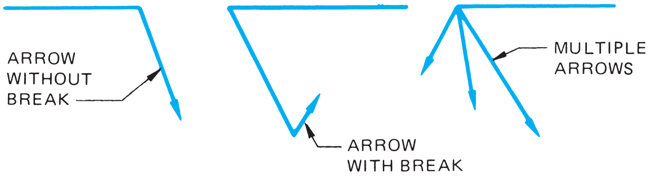


FIGURE 10.2 ■ Variations in the application of the arrow.

Multiple arrows may be added to the reference line to show the same weld required in several different locations, as in the case of a group of spot or fillet welds, Figure 10.2.

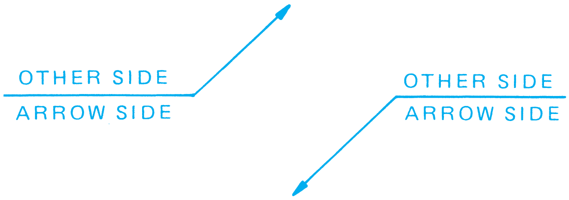
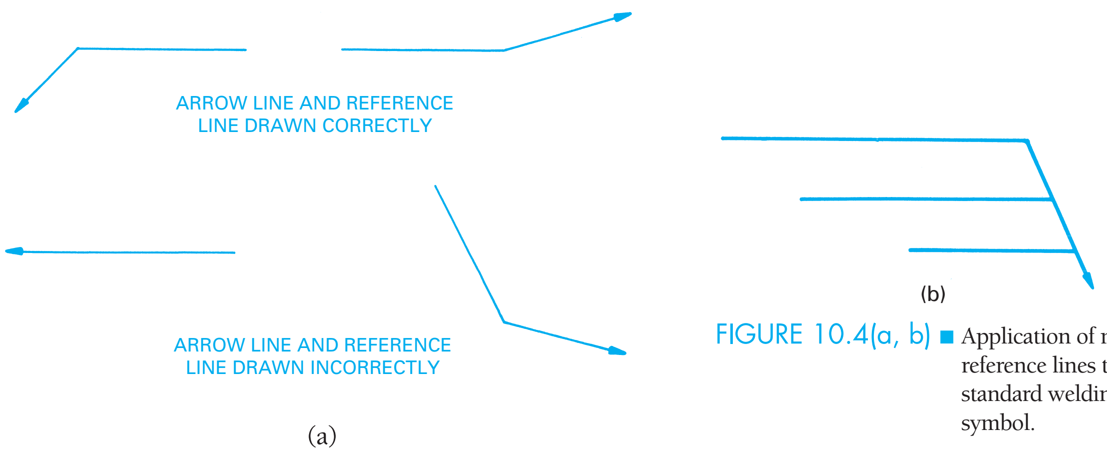


FIGURE 10.3 ■ Arrow side, other side locations.

The reference line of the welding symbol also has a particular significance that remains the same regardless of the elements added to it, and it is always drawn horizontal to the bottom of the print. The lower side of the reference line is termed the **arrow side** and the upper side is termed the **other side**, Figure 10.3. It should be noted that the terms “arrow side” and “other side” apply to the location of the weld with respect to the joint. The direction of the arrow has no bearing on the significance of the reference line (refer to Figure 10.4a). The arrow simply indicates a point to which the significance of the reference line and its elements are applied.


ARROW LINE AND REFERENCE LINE DRAWN CORRECTLY
ARROW LINE AND REFERENCE LINE DRAWN INCORRECTLY

(a)

(b)

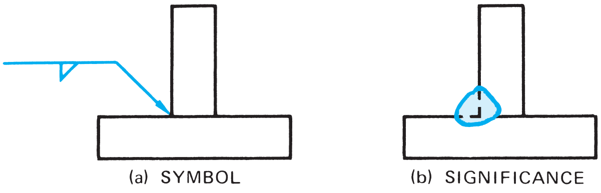
FIGURE 10.4(a, b) ■ Application of multiple reference lines to the standard welding symbol.

Multiple reference lines may also be used within the basic welding symbol, Figure 10.4(b). Additional information on multiple reference lines is presented later in this unit.

LOCATION OF WELD SYMBOL

When a weld symbol is placed on the reference line on the lower side of the line, the weld must be made on the arrow side of the joint.

Figure 10.5(a) illustrates the application of a welding symbol. The element shown on the reference line is the weld symbol for fillet ◸ or ◺. The symbol is located within the length of the reference line. In this case, the weld is to be made on the arrow side of the joint. The significance of the symbol is illustrated in Figure 10.5(b). Note that the vertical leg of the fillet weld symbol is *always* shown drawn to the left of the slanted side of the symbol.



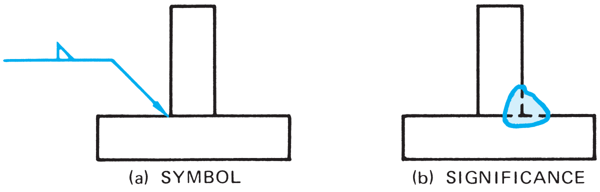
(a) SYMBOL (b) SIGNIFICANCE

FIGURE 10.5(a, b) ■ Fillet weld, arrow side.

If the fillet weld symbol is placed on the other side of the reference line, the welding symbol is made as shown in Figure 10.6(a). Its significance is shown in Figure 10.6(b).

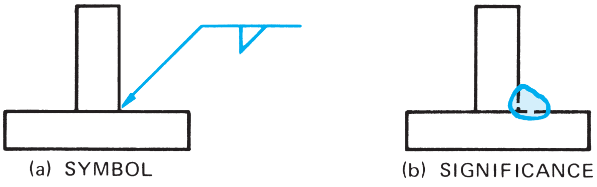
To summarize, Figure 10.7(a) and Figure 10.8(a) illustrate the alternate positions of the weld symbol on the reference line. The significance of the welding symbol in each case is illustrated by Figure 10.7(b) and Figure 10.8(b).

When weld symbols are placed on both sides of the reference line, the welds must be made on both sides of the joint, Figure 10.9 and Figure 10.10.



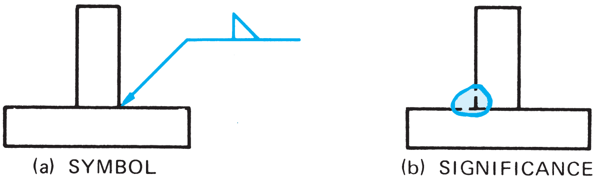
(a) SYMBOL (b) SIGNIFICANCE

FIGURE 10.6(a, b) ■ Fillet weld, other side.



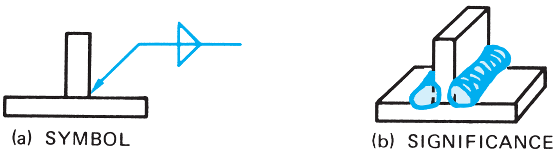
(a) SYMBOL (b) SIGNIFICANCE

FIGURE 10.7(a, b) ■ Fillet weld, arrow side.



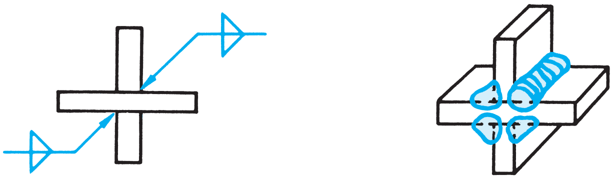
(a) SYMBOL (b) SIGNIFICANCE

FIGURE 10.8(a, b) ■ Fillet weld, other side.



(a) SYMBOL (b) SIGNIFICANCE

FIGURE 10.9(a, b) ■ Fillet weld, both sides.


(a) SYMBOL

(b) SIGNIFICANCE

FIGURE 10.10 ■ Two-joint fillet welds (both sides of joints).

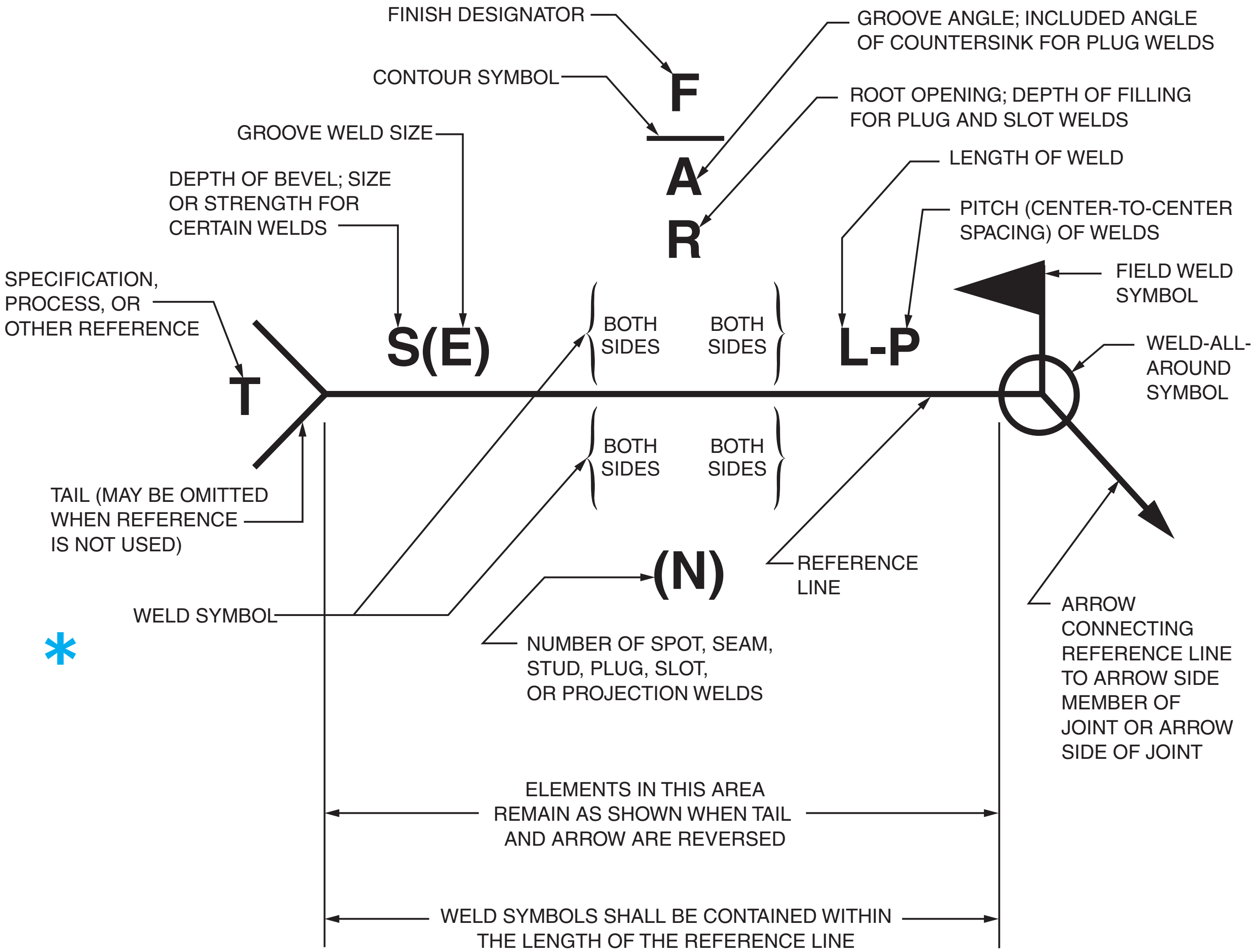

FINISH DESIGNATOR
CONTOUR SYMBOL
F
A
R
GROOVE ANGLE; INCLUDED ANGLE OF COUNTERSINK FOR PLUG WELDS
ROOT OPENING; DEPTH OF FILLING FOR PLUG AND SLOT WELDS
GROOVE WELD SIZE
DEPTH OF BEVEL; SIZE OR STRENGTH FOR CERTAIN WELDS
LENGTH OF WELD
PITCH (CENTER-TO-CENTER SPACING) OF WELDS
FIELD WELD SYMBOL
SPECIFICATION, PROCESS, OR OTHER REFERENCE
S(E)
BOTH SIDES
BOTH SIDES
L-P
WELD-ALL-AROUND SYMBOL
T
BOTH SIDES
BOTH SIDES
TAIL (MAY BE OMITTED WHEN REFERENCE IS NOT USED)
(N)
REFERENCE LINE
WELD SYMBOL
*
ARROW CONNECTING REFERENCE LINE TO ARROW SIDE MEMBER OF JOINT OR ARROW SIDE OF JOINT
NUMBER OF SPOT, SEAM, STUD, PLUG, SLOT, OR PROJECTION WELDS
ELEMENTS IN THIS AREA REMAIN AS SHOWN WHEN TAIL AND ARROW ARE REVERSED
WELD SYMBOLS SHALL BE CONTAINED WITHIN THE LENGTH OF THE REFERENCE LINE

FIGURE 10.11 ■ The welding symbol, its elements, and their locations.

ADDITIONAL WELDING SYMBOL ELEMENTS

A knowledge of the other elements added to the welding symbol and their placement is required before welding symbols on prints can be interpreted properly.

Each element applied to the basic welding symbol has a standard location with reference to the components of the welding symbol and to the other elements that are added to it. Figure 10.11 illustrates the different elements that may be added to the welding symbols and where they are located with respect to the arrow tail and reference lines.

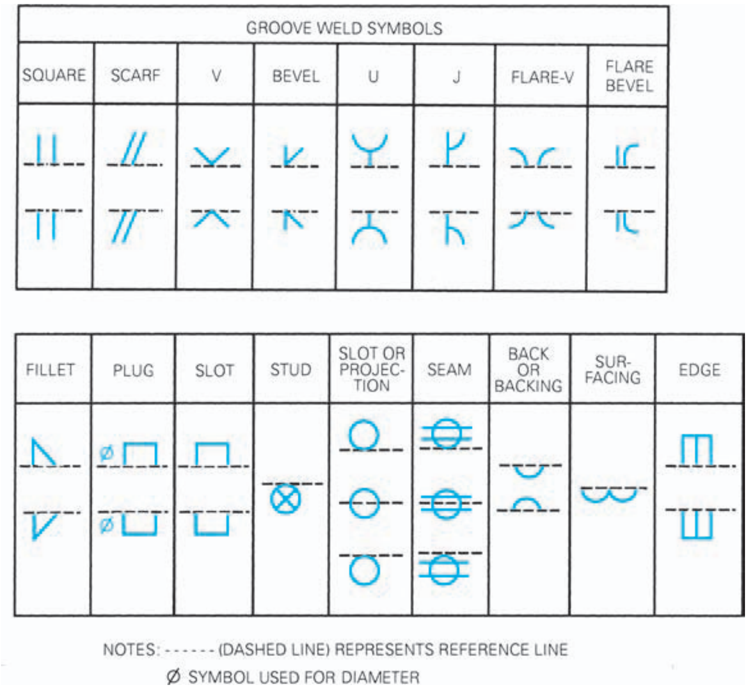
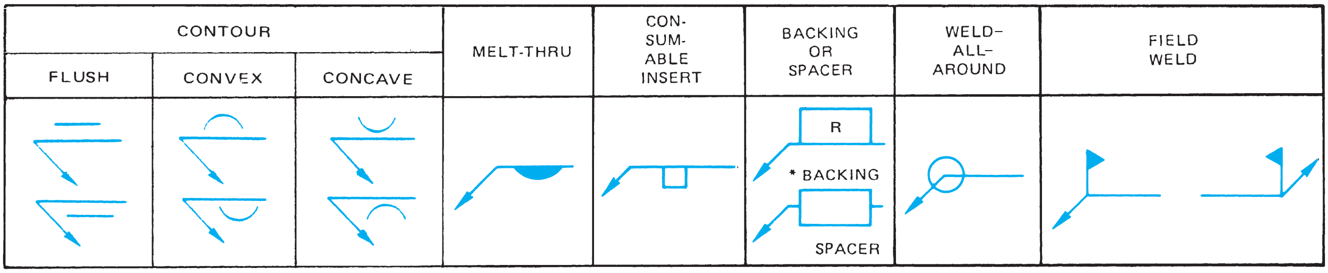


FIGURE 10.12 ■ Basic weld symbols.



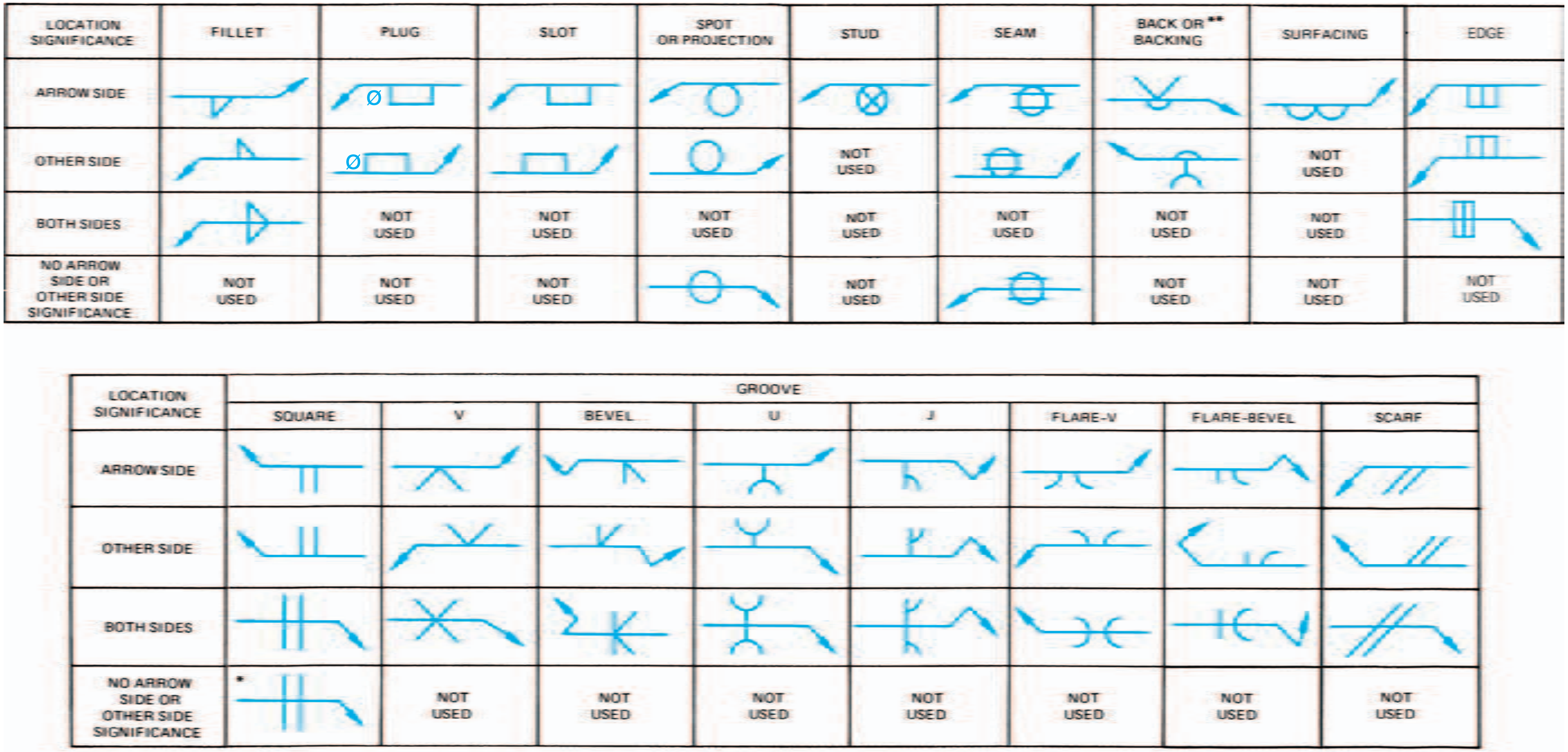
*THE LETTER "R" IS PLACED WITHIN THE BACKING MATERIAL SYMBOL TO SPECIFY REMOVAL OF BACKING MATERIAL UPON COMPLETION OF WELDING.

FIGURE 10.13 ■ Supplementary symbols.

The specific elements to be applied to the welding symbol to denote the types of welds are illustrated in Figure 10.12.

A standard set of supplementary symbols may also be added to the basic welding symbols, Figure 10.13.

Figure 10.14 shows the kinds of basic weld symbols applied to a welding symbol and their location with respect to the reference line of the basic welding symbol. Note that all symbols do not have an arrow side, other side, or both sides application as illustrated by the spacer symbol. Also note that an arrow with a break is generally necessary with bevel and J-groove symbols. In cases where it is obvious which joint member is to be prepared, an arrow with a break is not required.



LOCATION SIGNIFICANCE	FILLET	PLUG	SLOT	SPOT OR PROJECTION	STUD	SEAM	BACK OR BACKING **	SURFACING	EDGE
ARROW SIDE		Ø							
OTHER SIDE		Ø			NOT USED			NOT USED	
BOTH SIDES		NOT USED	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED	
NO ARROW SIDE OR OTHER SIDE SIGNIFICANCE	NOT USED	NOT USED	NOT USED		NOT USED		NOT USED	NOT USED	NOT USED

LOCATION SIGNIFICANCE	GROOVE							
	SQUARE	V	BEVEL	U	J	FLARE-V	FLARE-BEVEL	SCARF
ARROW SIDE								
OTHER SIDE								
BOTH SIDES								
NO ARROW SIDE OR OTHER SIDE SIGNIFICANCE	*	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED	NOT USED

*Used for ESW and EGW.

**Back or backing is specified in tail of welding symbol having a single reference line.

FIGURE 10.14 ■ Basic weld symbols and their location significance on the reference line.

OBSOLETE WELD SYMBOLS

Weld symbols are periodically revised to simplify the shape of the symbol, to consolidate several symbols into one, or to create a symbol to specify a newly developed welding technique.

The weld symbols illustrated in Figure 10.15 are called obsolete symbols because they have been replaced by new symbols. These symbols are not used on current prints; however, they are included for reference in older prints.

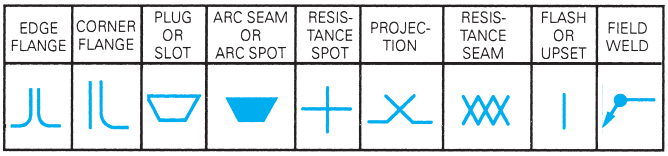


FIGURE 10.15 ■ Obsolete weld symbols.

PREFERRED SYMBOLS

Field Weld, Weld-All-Around Symbols

Welds extending continuously around the joint are indicated by placing the weld-all-around symbol ◯ at the break of the reference arrow line, Figure 10.16.

Welds not made in the shop are identified as field welds and are indicated by placing the field weld symbol ▶ or ◀ at the break in the reference arrow line. Note that the flag of the field weld symbol may point in either direction with respect to the arrow of the welding symbol, Figure 10.17. A field weld symbol and the weld-all-around symbol may be used together, Figure 10.17.

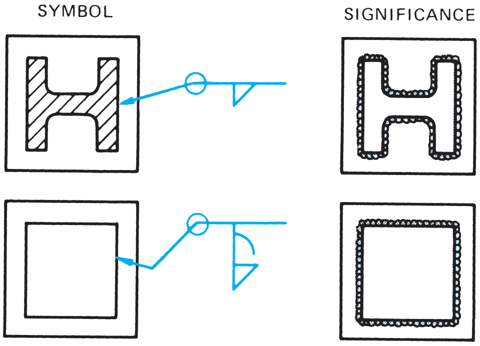


FIGURE 10.16 ■ Application of weld-all-around symbol.

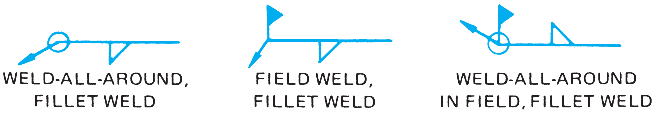

WELD-ALL-AROUND, FILLET WELD
FIELD WELD, FILLET WELD
WELD-ALL-AROUND IN FIELD, FILLET WELD

FIGURE 10.17 ■ Weld-all-around and field weld symbol.

CONTOUR AND FINISH SYMBOLS

Supplementary **contour** symbols are used with the weld symbols to indicate how the face of the weld is to be finished, Figure 10.18. In addition, **finish** symbols may be used with contour symbols to indicate the method to be used for forming the contour of the weld. Letter designations are used for this purpose: "C" for chipping, "G" for grinding, "M" for machining, "R" for rolling, "H" for hammering, "P" for planishing, and "U" for unspecified. Applying the letter "U" to a contour symbol signifies any method of finish may be used. A standard finish mark ✓ or V may be applied to the contour symbol with a numerical degree of finish shown above the finish mark, Figure 10.19.

Note that contour and finish symbols are placed on the same side of the reference line as the weld symbol. They are located directly above the weld symbol when the weld symbol is on the other side of the reference line, and directly below the weld symbol when it is located on the arrow side of the reference line.

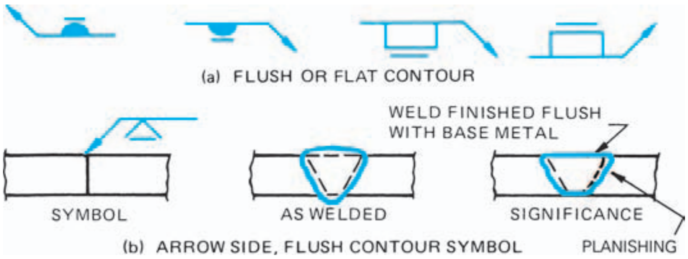

(a) FLUSH OR FLAT CONTOUR
WELD FINISHED FLUSH WITH BASE METAL
SYMBOL
AS WELDED
SIGNIFICANCE
(b) ARROW SIDE, FLUSH CONTOUR SYMBOL
PLANISHING

FIGURE 10.18 ■ Contour symbols.

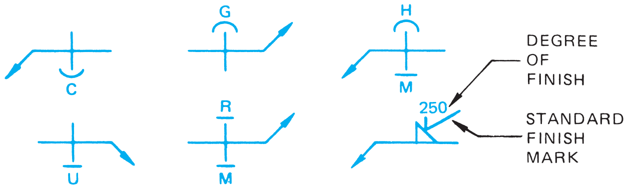
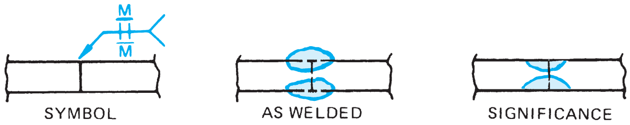
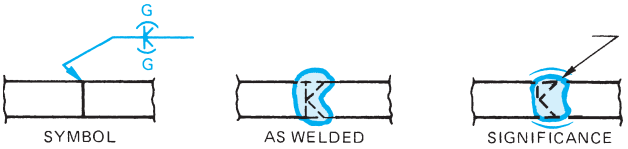


FIGURE 10.19 ■ Finish symbols.



(a) SQUARE GROOVE WELD, BOTH SIDES, MACHINE FLUSH SYMBOL



(b) DOUBLE BEVEL GROOVE WELD, BOTH SIDES, CONVEX CONTOUR SYMBOL (FINISH IS ACHIEVED BY GRINDING)

FIGURE 10.20 ■ Application of finish symbols.

The finish symbols commonly used are shown in Figure 10.19 and Figure 10.20. However, manufacturers may use their own designations for finishing. Although the degree of finish is not included in the AWS standards, many manufacturers do indicate a desired finish, particularly in the case of flush or flat welds. An example of such a specification is the 250-microinch finish requirement shown in Figure 10.19. The method of obtaining this finish may or may not be indicated.

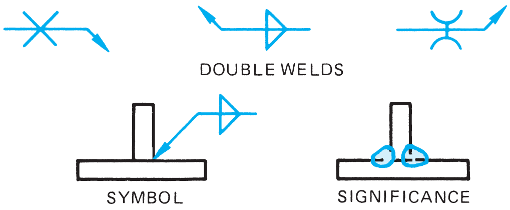
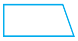
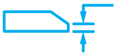


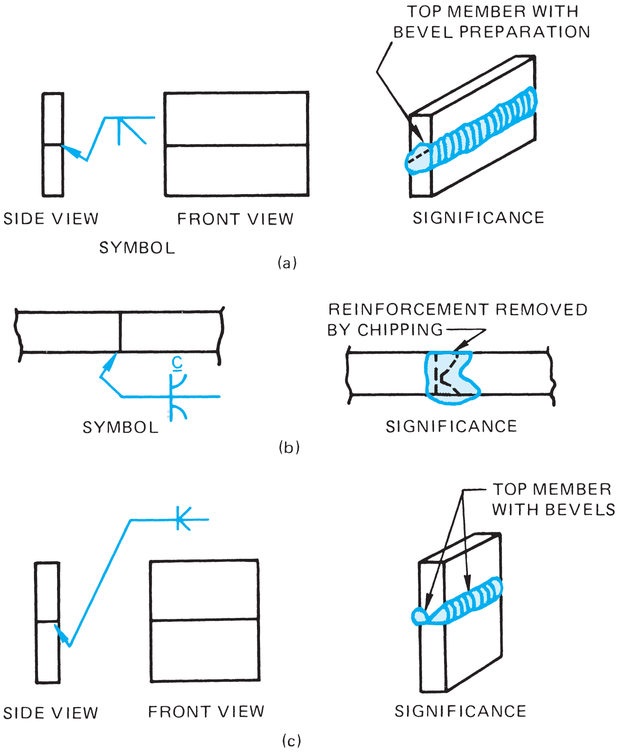
FIGURE 10.21 ■ Specifying more than one weld.

MULTIPLE WELD SYMBOLS

When more than one weld is required for a joint, a symbol is shown for each weld, Figure 10.21.

DESIGNATION OF MEMBER TO BE BEVELED

Certain welds require that one of the members of the joint be beveled before the weld is actually made. To be precise, a **bevel** describes an edge preparation with a sharp or “feather” edge (), or with a root face or “land” (). Machinists make a clear distinction between bevel and chamfer, but weld fabricators often simply apply the term “bevel” to both. When a bevel or J-groove weld symbol (either single or double) is used, the arrow will point with a definite break toward the member to be shaped. In Figure 10.22(a) and (c), the break in the arrow indicates that the upper member of the joint is to be beveled. In Figure 10.22(b), the right-hand member of the joint is to be prepared.

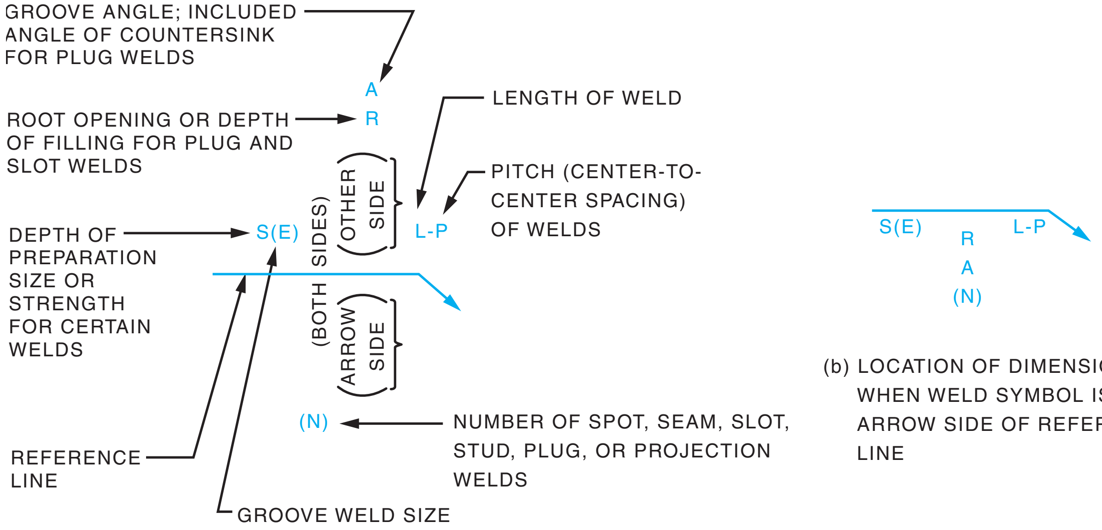


NOTE: BREAK IN ARROW POINTS TO MEMBER TO BE SHAPED

FIGURE 10.22 ■ Designation of weld on chamfered or beveled members.

DIMENSIONS ON WELDING SYMBOLS

There are definite locations on the welding symbol for designations of the size or strength of the weld, length of the weld, pitch (center-to-center spacing), and the number of welds (in the case of plug, slot, spot, stud, seam, or projection welds). These locations are determined by the side of the reference line on which the weld symbol is placed, Figure 10.23(a) and (b).


GROOVE ANGLE; INCLUDED ANGLE OF COUNTERSINK FOR PLUG WELDS
A
ROOT OPENING OR DEPTH OF FILLING FOR PLUG AND SLOT WELDS
R
LENGTH OF WELD
PITCH (CENTER-TO-CENTER SPACING) OF WELDS
(OTHER SIDE)
(BOTH SIDES)
(ARROW SIDE)
L-P
DEPTH OF PREPARATION SIZE OR STRENGTH FOR CERTAIN WELDS
S(E)
(N)
NUMBER OF SPOT, SEAM, SLOT, STUD, PLUG, OR PROJECTION WELDS
REFERENCE LINE
GROOVE WELD SIZE
S(E)
R
A
(N)
L-P

(a) LOCATION OF DIMENSION WHEN WELD SYMBOL IS ON OTHER SIDE OF REFERENCE LINE

(b) LOCATION OF DIMENSIONS WHEN WELD SYMBOL IS ON ARROW SIDE OF REFERENCE LINE

FIGURE 10.23 ■ Location of dimensions.

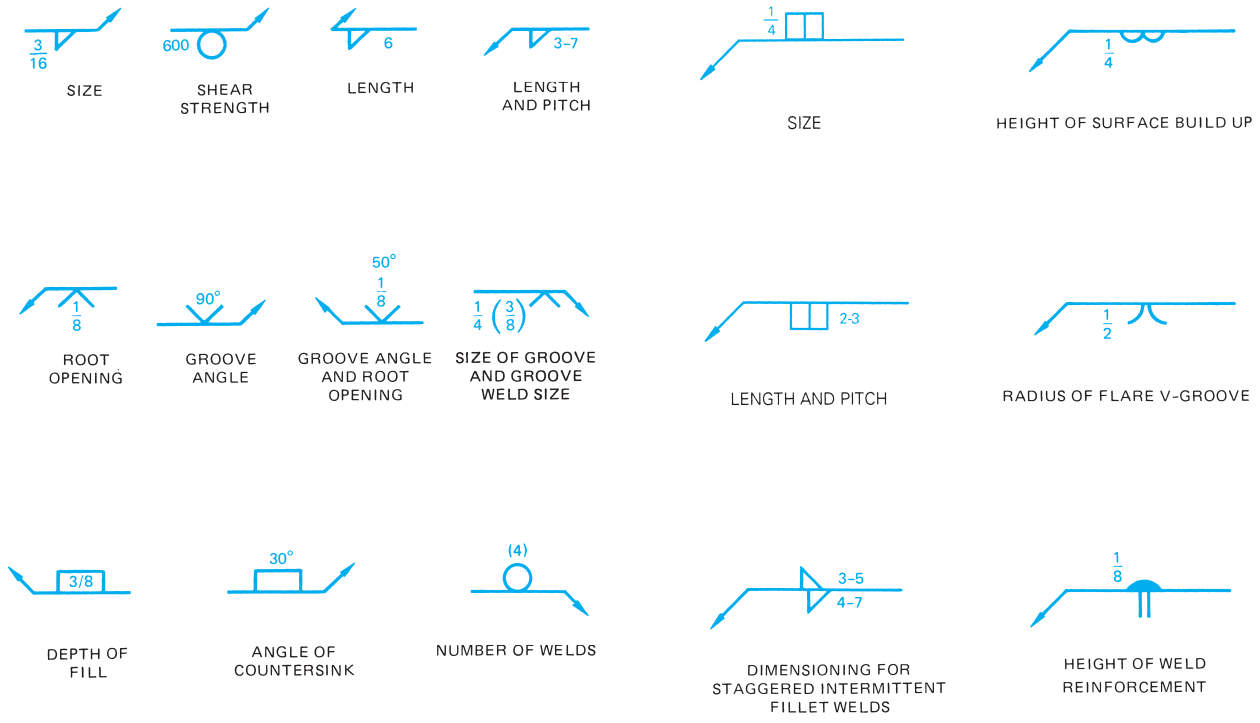


FIGURE 10.24 ■ Size dimensions applied to weld symbols.

The location for the number of spot or projection welds may be either above or below the symbol since there may be no arrow side or other side significance for these symbols.

Figure 10.24 shows how dimensions are applied to symbols. A detailed explanation of their application is presented in later units which refer to specific welds.

DESIGNATION OF SPECIAL INFORMATION

Certain operations require a specific welding process, a particular type of electrode, or other information necessary to complete the weld. In this case, a note can be placed in the tail of the reference line (using standard welding abbreviations), Figure 10.25.

Note that the term "back gouge" indicates removal of weld metal and base metal from the other side of a partially welded joint. This ensures complete joint penetration when welding the gouged side of the joint.

There are circumstances when weld symbols are not added to the reference line of a welding symbol. This may occur when the drawing permits optional joint preparation with only complete penetration specified. This is so indicated by placing the letters "**CJP**" in the tail of the arrow and omitting the weld symbol, Figure 10.26. A note is added to the print that signifies this option.

It should be noted that when the letters "CJP" are found in the tail of the arrow, a complete joint penetration weld is required regardless of the type of weld or joint preparation that is used.

The welding symbol may not always be adequate to denote the weld required, such as for skewed joints (joints that deviate from a straight line). When this is the case, a cross section or detail drawing of the joint and shape of the weld is shown on the print. Data, in the form of notes, may be added to the drawing to further clarify the joint or weld required. Reference is made to the detail or section drawing by a note or notes added to the reference line of the welding symbol with an arrow side, other side, or both sides significance, Figure 10.26 and Figure 10.27. In such cases, a weld symbol is not shown on the reference line.

A weld symbol may be omitted from the reference line if the type of joint preparation is not specified. The weld size is indicated on the desired side(s) of the reference line, Figure 10.28.

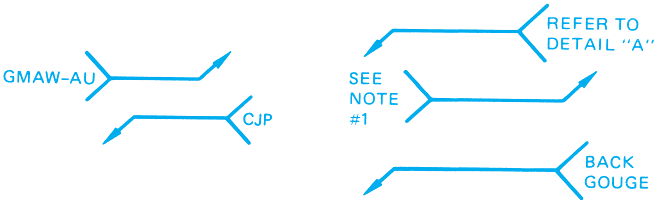
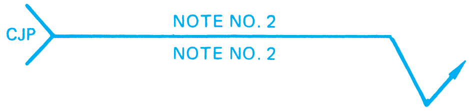


FIGURE 10.25 ■ Specifying additional information in the tail of the welding symbol.



NOTE: TYPE WELD AND JOINT PREPARATION OPTIONAL

FIGURE 10.26 ■ Specifying "Complete Joint Penetration" (CJP) in the tail of the welding symbol.

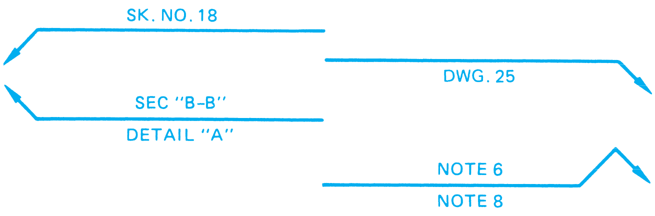


FIGURE 10.27 ■ Application of information to reference line of welding symbol.

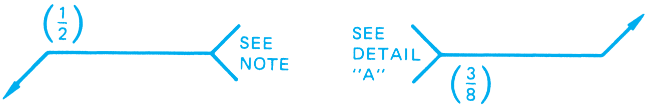


FIGURE 10.28 ■ Size of groove weld applied to welding symbol without reference to a weld symbol.

LOCATION OF THE WELDING SYMBOL ON ORTHOGRAPHIC VIEWS

The welding symbol can be placed on any of the orthographic views, but is generally shown on the view that best illustrates the joint. The location of the welding symbol on each view is illustrated in Figure 10.29. However, when the symbol is shown on one view, it is not necessary to include it on any of the other views. In Figure 10.29, note that the front view gives the best indication of the joint; therefore, the symbol should be added to this view.

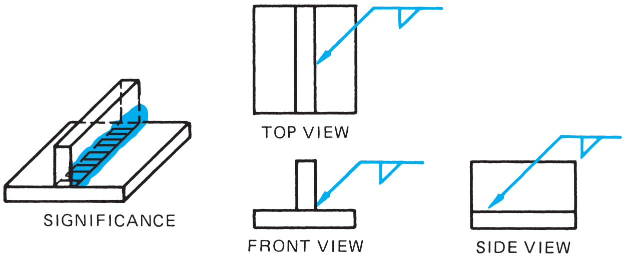


FIGURE 10.29 ■ Symbol may be placed in any view in the orthographic projection.

DUPLICATE WELDS

To save drafting time and to reduce drafting costs, it is common practice to designate similar welds by additional (multiple) arrows, Figure 10.30(a), or by an indication placed in the tail of the symbol, Figure 10.30(b). It should be noted, however, that any indication such as "4 places" must refer to obvious welds. If there is any doubt where these "4 places" are on the print, separate symbols for each weld should be applied. Note that the abbreviation "**TYP**" for **typical** may be used to indicate a repetition of identical welds and is shown in the tail of the welding symbol.

MULTIPLE REFERENCE LINES AND THEIR APPLICATIONS

Additional reference lines may be applied to the basic welding symbol to show: (1) a sequence of welding operations where the first operation must be completed before the next can be performed and (2) supplementary symbols applicable to the weld symbol shown on the first reference line. Note that the first reference line is the one located closest to the arrow, Figure 10.31(a, b, and c).

When multiple reference lines are applied to the basic welding symbol, the weld-all-around and field weld symbols may be added to one or all of the reference lines. Tails may be added similarly, Figure 10.32.

WELDING ABBREVIATIONS

Standard abbreviations or letter designations for the various welding processes developed by the AWS are universally accepted by the welding industry.

The welder will find these standard abbreviations on prints used for the fabrication of weldments. Table 10.1, Table 10.2, and Table 10.3 illustrate the letter designations used for welding processes, cutting processes, and the methods of applying these processes. These letter designations are used with welding symbols or are included in the notes on prints. Note that the abbreviation for each welding process ends with the letter "W" and for each cutting process with the letter "C".

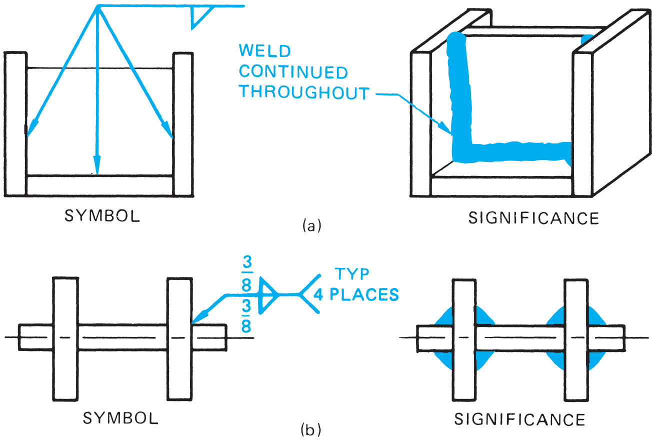


FIGURE 10.30(a, b) ■ Duplicate welds.

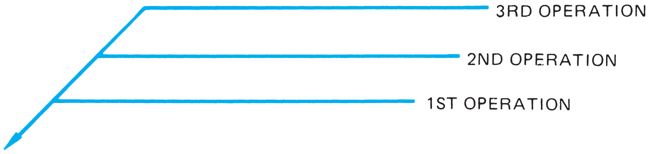


FIGURE 10.31(a) ■ Sequence of operations signified by multiple reference lines.

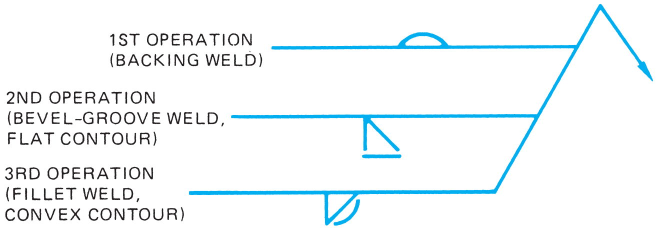


FIGURE 10.31(b) ■ Application of weld symbols to multiple reference lines.

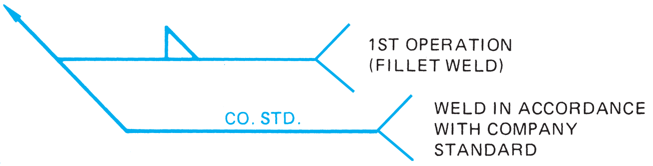


FIGURE 10.31(c) ■ Application of supplementary data to second reference line.

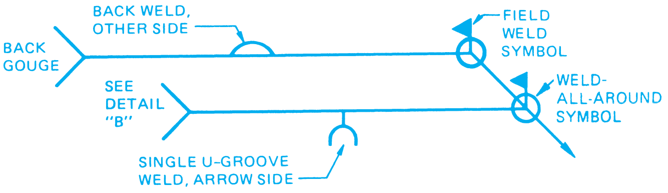


FIGURE 10.32 ■ Application of field weld symbol, and tails to multiple reference line.

AAW	Air Acetylene Welding	GTAW	Gas Tungsten Arc Welding
AB	Arc Brazing	GTAW-P	Gas Tungsten Arc Welding–Pulsed Arc
AHW	Atomic Hydrogen Welding	HPW	Hot Pressure Welding
AW	Arc Welding	IB	Induction Brazing
B	Brazing	IRB	Infrared Brazing
BB	Block Brazing	IW	Induction Welding
BMAW	Bare Metal Arc Welding	LBW	Laser Beam Welding
CAW	Carbon Arc Welding	OAW	Oxyacetylene Welding
CAW-G	Gas Carbon Arc Welding	OFW	Oxyfuel Gas Welding
CAW-S	Shielded Carbon Arc Welding	OHW	Oxyhydrogen Welding
CAW-T	Twin Carbon Arc Welding	PAW	Plasma Arc Welding
CEW	Coextrusion Welding	PEW	Percussion Welding
CW	Cold Welding	PGW	Pressure Gas Welding
DFB	Diffusion Brazing	PW	Projection Welding
DFW	Diffusion Welding	RB	Resistance Brazing
DP	Dip Brazing	ROW	Roll Welding
EASP	Electric Arc Spraying	RSEW	Resistance Seam Welding
EBW	Electron Beam Welding	RSEW-HF	Resistance Seam Welding–High Frequency
EBW-HV	Electron Beam Welding–High Vacuum	RSEW-I	Resistance Seam Welding–Induction
EBW-MV	Electron Beam Welding–Medium Vacuum	RSW	Resistance Spot Welding
EBW-NV	Electron Beam Welding–Nonvacuum	RW	Resistance Welding
EGW	Electrogas Welding	SAW	Submerged Arc Welding
ESW	Electroslag Welding	SAW-S	Series Submerged Arc Welding
EXW	Explosion Welding	SMAW	Shielded Metal Arc Welding
FB	Furnace Brazing	SSW	Solid-State Welding
FCAW	Flux Cored Arc Welding	SW	Stud Arc Welding
FLB	Flow Brazing	TB	Torch Brazing
FLOW	Flow Welding	TCAB	Twin Carbon Arc Brazing
FOW	Forge Welding	TW	Thermit Welding
FRW	Friction Welding	USW	Ultrasonic Welding
FW	Flash Welding	UW	Upset Welding
GMAW	Gas Metal Arc Welding	UW-HF	Upset Welding–High Frequency
GMAW-P	Gas Metal Arc Welding–Pulsed Arc	UW-I	Upset Welding–Induction
GMAW-S	Gas Metal Arc Welding–Short Circuiting Arc		

TABLE 10.1 ■ Letter designations for welding processes.

AAC	Air Carbon Arc Cutting
AC	Arc Cutting
AOC	Oxygen Arc Cutting
CAC	Carbon Arc Cutting
EBC	Electron Beam Cutting
FOC	Chemical Flux Cutting
GMAC	Gas Metal Arc Cutting
GTAC	Gas Tungsten Arc Cutting
LBC	Laser Beam Cutting
LBC-A	Laser Beam Cutting–Air
LBC-EV	Laser Beam Cutting–Evaporative
LBC-IG	Laser Beam Cutting–Inert Gas
LBC-O	Laser Beam Cutting–Oxygen
LOC	Oxygen Lance Cutting
MAC	Metal Arc Cutting
OC	Oxygen Cutting
OFC	Oxyfuel Gas Cutting
OFC-A	Oxyacetylene Cutting
OFC-H	Oxyhydrogen Cutting
OFC-N	Oxynatural Gas Cutting
OFC-P	Oxypropane Cutting
PAC	Plasma Arc Cutting
POC	Metal Powder Cutting
SMAC	Shielded Metal Arc Cutting
TC	Thermal Cutting

TABLE 10.2 ■ Letter designations for cutting processes.

AU	Automatic
ME	Machine
MA	Manual
SA	Semiautomatic

TABLE 10.3 ■ Letter designations for applying welding processes.

Note: These suffixes may be used if it is desired to indicate the methods of applying the welding processes, Figure 10.36.

Figure 10.33 shows how letter designations for welding processes are applied to welding symbols. Note that in each case the letters are located in the tail of the arrow.

When a contour symbol is used, an abbreviation for the method of finish may be included, Figure 10.34. All letters shown on prints do not necessarily represent letter designations or abbreviations. For example, letters can be used with specifications, Figure 10.35. In this case, the letter "A" has no significance except to identify the specification to which reference is made.

There are other occasions when letters are used solely for identification purposes. As welders become familiar with reading prints, they will be able to distinguish between the letters applied as abbreviations and those used to identify specifications.

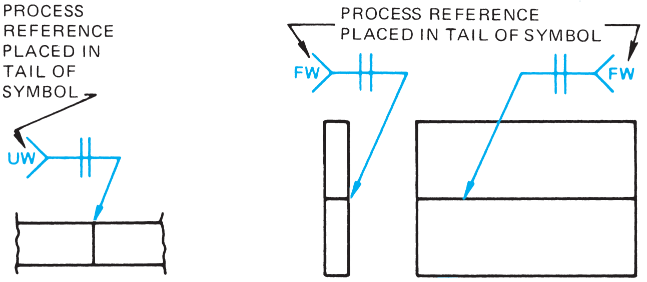

PROCESS REFERENCE PLACED IN TAIL OF SYMBOL
UW
PROCESS REFERENCE PLACED IN TAIL OF SYMBOL
FW
FW

FIGURE 10.33 ■ Application of abbreviations to welding symbols.

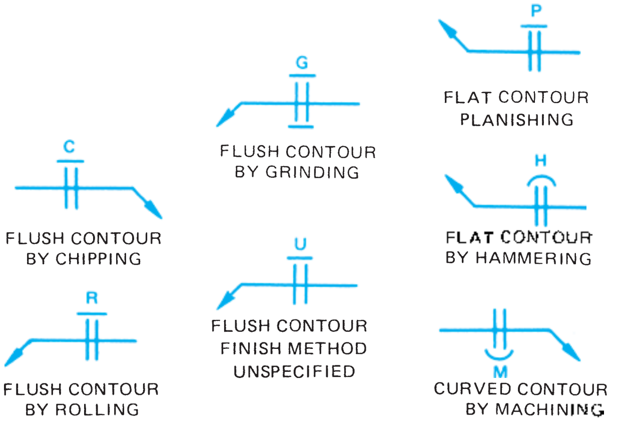

P
FLAT CONTOUR PLANISHING
G
FLUSH CONTOUR BY GRINDING
C
FLUSH CONTOUR BY CHIPPING
H
FLAT CONTOUR BY HAMMERING
U
FLUSH CONTOUR FINISH METHOD UNSPECIFIED
R
FLUSH CONTOUR BY ROLLING
M
CURVED CONTOUR BY MACHINING

FIGURE 10.34 ■ Finish abbreviations, also called finish symbols.

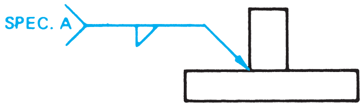
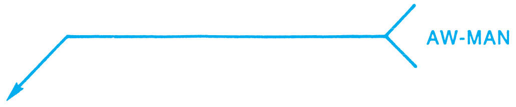


FIGURE 10.35 ■ Letter "A" used for identification of specification.



Note: AW=ARC welding process
MA=Method used to do welding

FIGURE 10.36 ■ Suffixes indicating method of applying welding process.

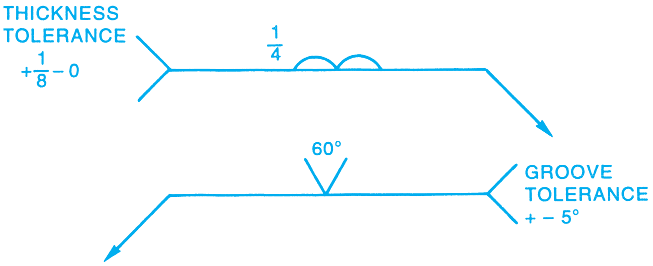


FIGURE 10.37 ■ Application of weld symbol dimension tolerance.

WELD SYMBOL DIMENSION TOLERANCE

A tolerance applicable to a weld may be shown as a dimension within the tail of the welding symbol, Figure 10.37.

SUMMARY

1. The terms arrow side, other side, and both sides refer to the location of the weld with relation to the-joint.
2. The elements that can be added to the basic weld symbols are: contour and finish desired; dimensions such as size, strength, length, pitch, angle of groove, angle of counter sink, root opening, and depth of preparation; combinations of different types of weld symbols; number of welds (quantity of resistance-spot and projection welds required); field weld and weld-all-around symbols; specification and process references; and detail references for special welds and test symbols.
3. By application of standard elements to the reference line and tail of the welding symbol, and by use of the arrow or multiple arrows to indicate the location of welds, the necessary information is provided to the welder for performance of required welds.
4. Multiple reference lines may be used to indicate the sequence of operations and supplementary data applicable to the weld symbols shown.
5. When the information shown by the welding symbol is not adequate, it is supplemented by written data, notes, and specifications, and by detail and section drawings.

There are standard abbreviations or letter designations for the various welding processes that are applied to the tail of the welding symbol when it is appropriate to do so.

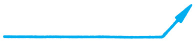
UNIT 10: REVIEW A

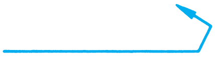
Graph paper is provided at the end of this review for your use.

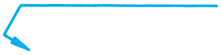
1. What is the purpose of a weld symbol?

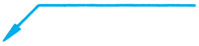
____

2. Identify the arrow side and other side of the welding symbols shown.

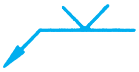


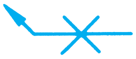


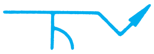




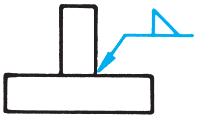
3. On which side of the reference lines are the following weld symbols located?

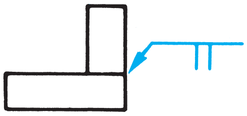
a.


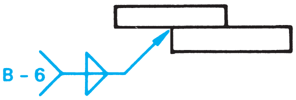
b.


c.


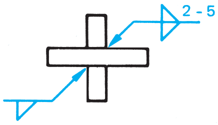
4. Indicate the side of the joint to be welded by placing an X at the appropriate point(s) on the joint.


a.


b.



c.



d.

5. Describe the types of welds specified in question 4.

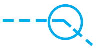
a. ______________________________

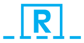
b. ______________________________

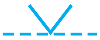
c. ______________________________

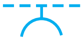
d. ______________________________

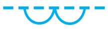
6. Give the significance of the following symbols.





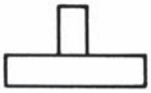


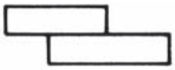


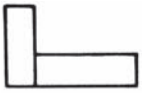


7. Sketch and label the symbols used to indicate the contour of a weld.

8. Apply a welding symbol to show a fillet weld to the following joints as indicated in a, b, and c.


a. Both sides


b. Arrow side


c. Other side

9. Describe the difference between a weld symbol and a welding symbol.

____

____

10. What information is usually placed in the tail of the symbol?

____

____

____

____

11. Give two methods used to specify the size of a weld.

____

____

12. Give two reasons for using standard letter designations.

____

____

13. Where are letter designations principally found on a welding symbol?

____

14. List four categories of welding letter designations.

____

____

15. Do all letters found on a print represent abbreviations or letter designations? ______

Give a reason for your answer.

____

____

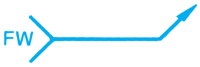
16. How is it possible to distinguish a welding abbreviation or letter designation from another standard abbreviation?

____

____

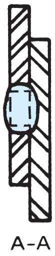
17. Interpret the significance of the letters shown in the following illustrations (a through f).

a.



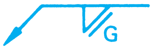
FW = ______

b.



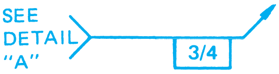
A-A = ______

c.



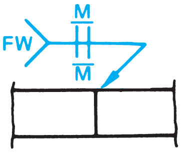
G = ______

d.



"A" = ______

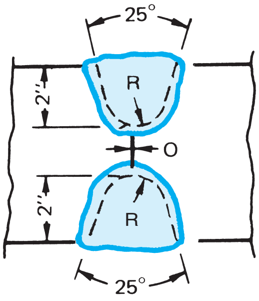
e.



FW = ______

M = ______

f.



R = ______

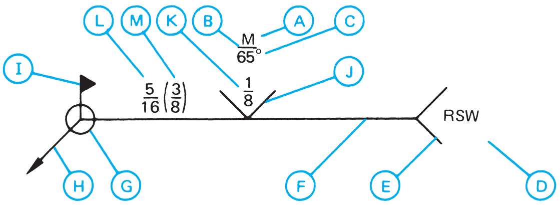
O = ______

18. In question 17a, identify the kind of material represented by the section lines.

____

19. Explain the significance of each element shown in the following welding symbols a. and b.

a.



Ⓐ ______

Ⓑ ______

Ⓒ ______

Ⓓ ______

Ⓔ ______

Ⓕ ______

Ⓖ ______

Ⓗ ______

Ⓘ ______

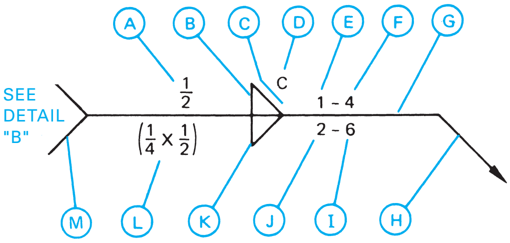
Ⓙ ______

Ⓚ ______

Ⓛ ______

Ⓜ ______

b.



Ⓐ ______

Ⓑ ______

Ⓒ ______

Ⓓ ______

Ⓔ ______

Ⓕ ______

Ⓖ ______________________________

Ⓗ ______________________________

Ⓘ ______________________________

Ⓙ ______________________________

Ⓚ ______________________________

Ⓛ ______________________________

Ⓜ ______________________________

20. a. Explain the abbreviation “CJP.”

____

b. Where is it usually located on the welding symbol?

____

21. a. Explain the abbreviation “R” when used with a backing symbol.

____

b. Where is this abbreviation usually found on the welding symbol?

____

22. a. Which is the first weld to be made in the following welding symbol?

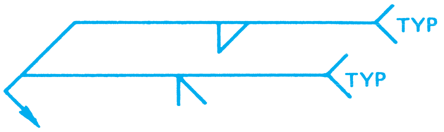
____

b. Which is the second weld to be made?

____

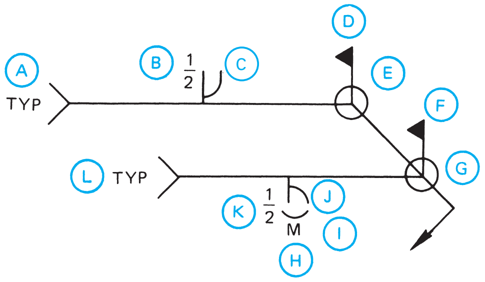
c. Explain the significance of the broken arrow line.

____



23. Explain the significance of each element shown in the following welding symbols in a. and c.

a.



Ⓐ ______________________________

Ⓑ ______________________________

Ⓒ ______________________________

Ⓓ ______________________________

Ⓔ ______________________________

Ⓕ ______________________________

Ⓖ ______________________________

Ⓗ ______________________________

Ⓘ ______________________________

Ⓙ ______________________________

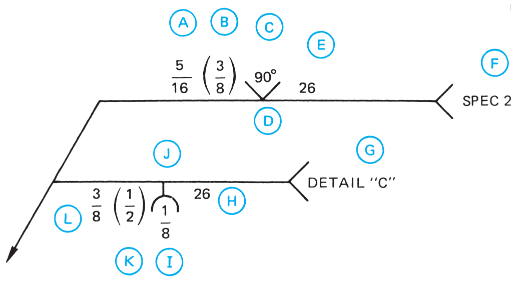
Ⓚ ______________________________

Ⓛ ______________________________

b. Should the other side weld be made first?

____

c.



Ⓐ ______________________________

Ⓑ ______________________________

Ⓒ ______________________________

Ⓓ ______________________________

Ⓔ ______________________________

Ⓕ ______________________________

Ⓖ ______________________________

Ⓗ ______________________________

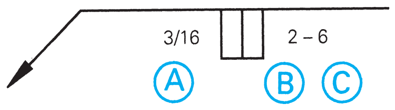
Ⓘ ____________________

Ⓙ ____________________

Ⓚ ____________________

Ⓛ ____________________

24. Identify the dimensions shown on the following welding symbol:

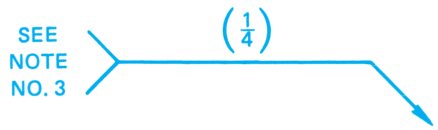


Ⓐ ____________________

Ⓑ ____________________

Ⓒ ____________________

25. Explain the significance of the following weld symbol.

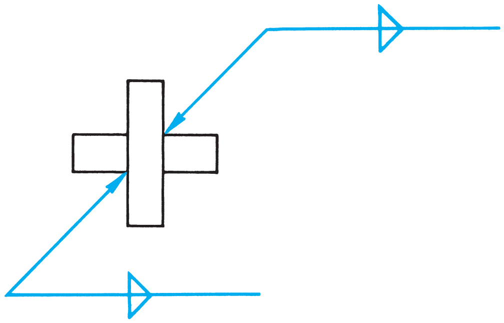


NOTE
NO. 3: ALL WELDS TO BE V-GROOVE
WITH FULL PENETRATION

____

____

26. Prepare a right oblique sketch which illustrates the significance of the following weld symbols.



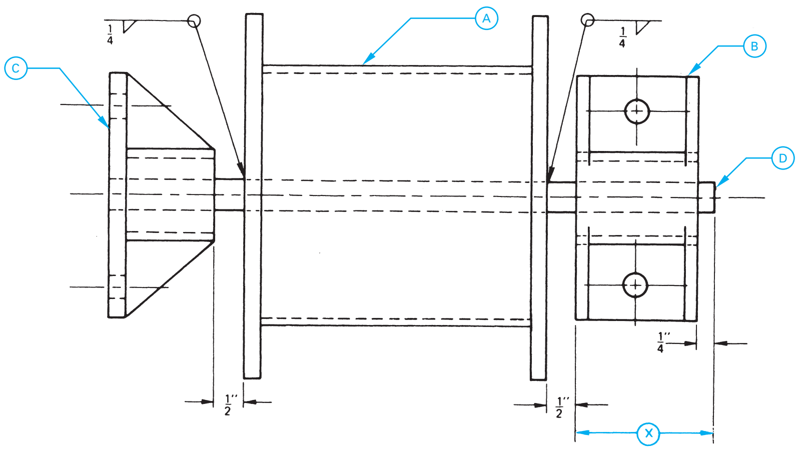
27. a. Identify the symbol that has replaced the now obsolete corner flange and edge flange symbols.

____

b. Using a sketch, show an other side version of this symbol.

c. Can a both sides application of this weld symbol be used with a welding symbol?

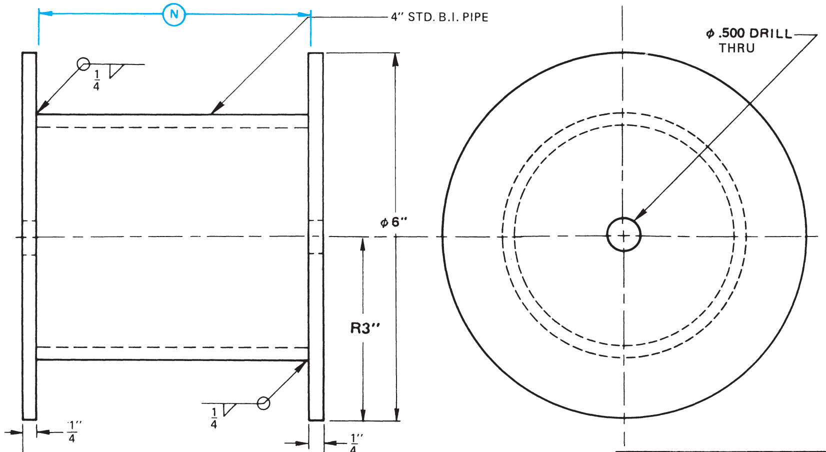
____



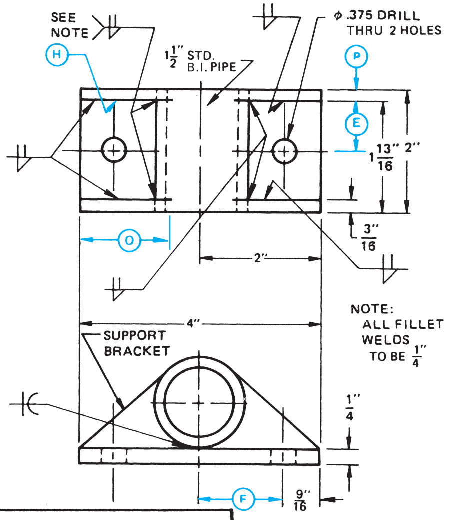
A	DRUM
B	BEARING (LARGE)
C	BEARING (SMALL)
D	SHAFT 1/2" X 10-1/8" LONG - CRS

CABLE DRUM		
QTY 1	ORDER NO. 101	SPEC
SCALE 5/8" = 1"	MATL SEE DETAILS	
DRAWN BY: L. GRADY		DATE:
DRAWING NO.	TOLERANCE	
COMPANY NAME		

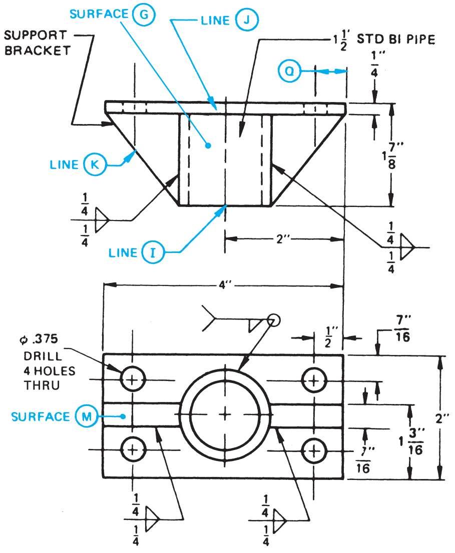
DETAIL AND
ASSEMBLY PRINTS
FOR
CABLE DRUM



Ⓐ DRUM



Ⓑ LARGE BEARING



Ⓒ SMALL BEARING

CABLE DRUM DETAILS		
QTY 1 EACH PER ASSEMBLY	ORDER NO.	MATL CRS
	SCALE 5/8" = 1"	SPEC
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 44	TOLERANCE	
COMPANY NAME		

EDITOR'S NOTE: REDUCED PRINT. FOLLOW STATED DIMENSIONS ONLY. NOT TO BE SCALED.

UNIT 10: REVIEW B

Refer to the drawing, Cable Drum, page 136.

1. Explain the significance of the different welding symbols found in the details for parts Ⓐ, Ⓑ, and Ⓒ.

   Ⓐ ____________________

   Ⓑ ____________________

   Ⓒ ____________________

2. Explain the significance of the welding symbols found in the assembly print.

   ____

   ____

   ____

3. Why has a tail been omitted on many of the welding symbols found on these prints?

   ____

   ____

4. What is the inside diameter of the pipe for part Ⓐ? (Note: Refer to Appendix 3.)

   Ⓐ ____________________

5. What are the dimensions for the following distances in the detail prints?

   Ⓝ ____________________

   Ⓟ ____________________

   Ⓠ ____________________

   Ⓔ ____________________

   Ⓧ ____________________

6. What is the overall length of the assembled unit?

   ____

7. Determine the approximate total lengths of welds for parts Ⓐ, Ⓑ, and Ⓒ.

   Ⓐ ____________________

   Ⓑ ____________________

   Ⓒ ____________________

8. What is the total length of 1½″ pipe required for making the Cable Drum?

   ____

9. State whether line Ⓗ (in part Ⓑ) represents a vertical or horizontal surface in the view shown in the lower part of the print.

   ____

10. Name the views used to show parts Ⓐ and Ⓑ.

    ____

    ____

11. Refer to the detail for part Ⓒ and answer the following questions.

    a. What surface in the front view represents line Ⓚ?

    ____

    b. What surface in the front view represents line Ⓘ?

    ____

12. With a simple sketch, show the significance of the note that indicates the size of the fillet welds for part Ⓑ.

13. Give the approximate overall sizes for the support brackets used in fabricating parts Ⓑ and Ⓒ.

    Ⓑ ____________________

    Ⓒ ____________________

14. What material is specified for part Ⓓ?

15. How is the shaft fastened to the large drum?

16. How many support brackets are required for the large bearing?

17. a. What weld is specified for fastening the end plates to the BI pipe?

    b. How many inches of weld is required for each?

NOTES:

1. Refer to Appendix 9 to answer 17b, or use the following formula:

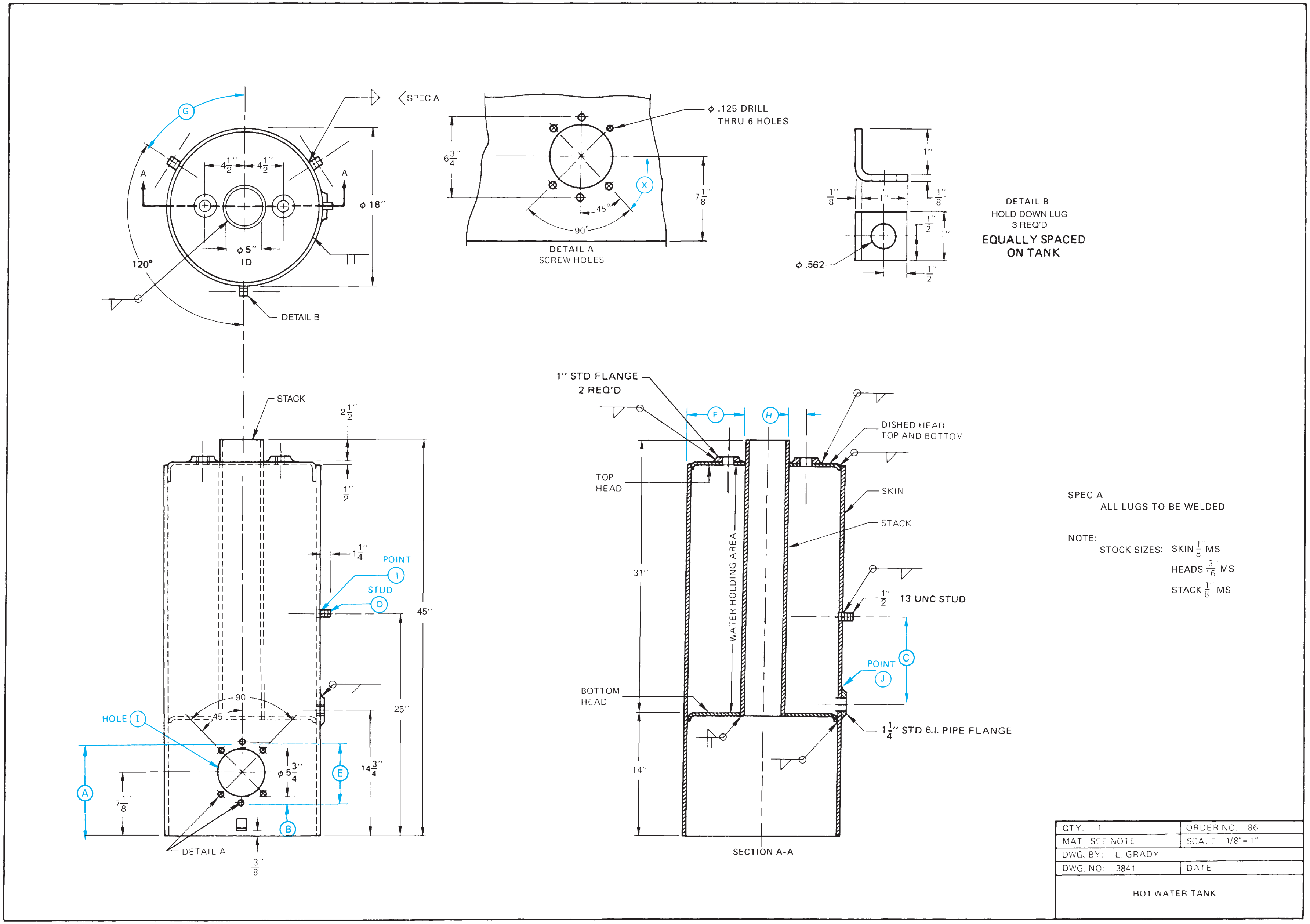
   Diameter of a circle × 3.1416 or $^{22}/_{7}$ equals its circumference.

2. The constants 3.1416 and $^{22}/_{7}$ are indicated by the Greek letter π or Pi.

Examples:

A diameter (ϕ) of 2" × π equals a circumference of 6.2832 (*decimal fraction*).

A diameter of 4" × Pi equals a circumference of 12 $^{4}/_{7}$" (*common fraction*).



EDITOR'S NOTE: REDUCED PRINT. FOLLOW STATED DIMENSIONS ONLY. NOT TO BE SCALED.
FULL SIZE DRAWING IS PROVIDED AT THE BACK OF THE TEXT.

SUMMARY REVIEW NO. 2A

Refer to the drawing, Hot Water Tank, page 140.

1. How thick is the bottom head?

____

2. How thick is the material used in the stack?

____

3. How thick is the skin of the tank?

____

4. What is the diameter and length of stud Ⓓ?

____

5. What size and how many screw holes are used around hole Ⓘ?

____

6. What are distances Ⓕ and Ⓗ?

____

7. Approximately how many inches and what type of weld are required to join the stack to the head at the top of the tank? (Give answer within ½″.)

____

8. What type of weld is required at point Ⓙ?

____

9. What type of weld is used to join the hold-down lugs to the tank?

____

10. How many hold-down lugs are needed for this order?

____

11. a. Do all these lugs require the same type of weld?

____

b. Explain your answer.

____

12. What is the angle of Ⓖ?

____

13. What is the distance from the top of the top head to the bottom of the bottom head?

____

14. What are the dimensions of Ⓐ and Ⓔ?

Ⓐ ________________________________

Ⓔ ________________________________

15. What is the distance from the bottom of the water-holding tank to the bottom of the hold-down lugs?

____

16. How many degrees apart on center are the hold-down lugs?

____

17. What types of welds are required to join the stack to the bottom of the head?

____

18. What is the inside diameter of the tank?

____

19. Make a list of materials required for the fabrication of the tank (list all sizes).

Bill of Materials

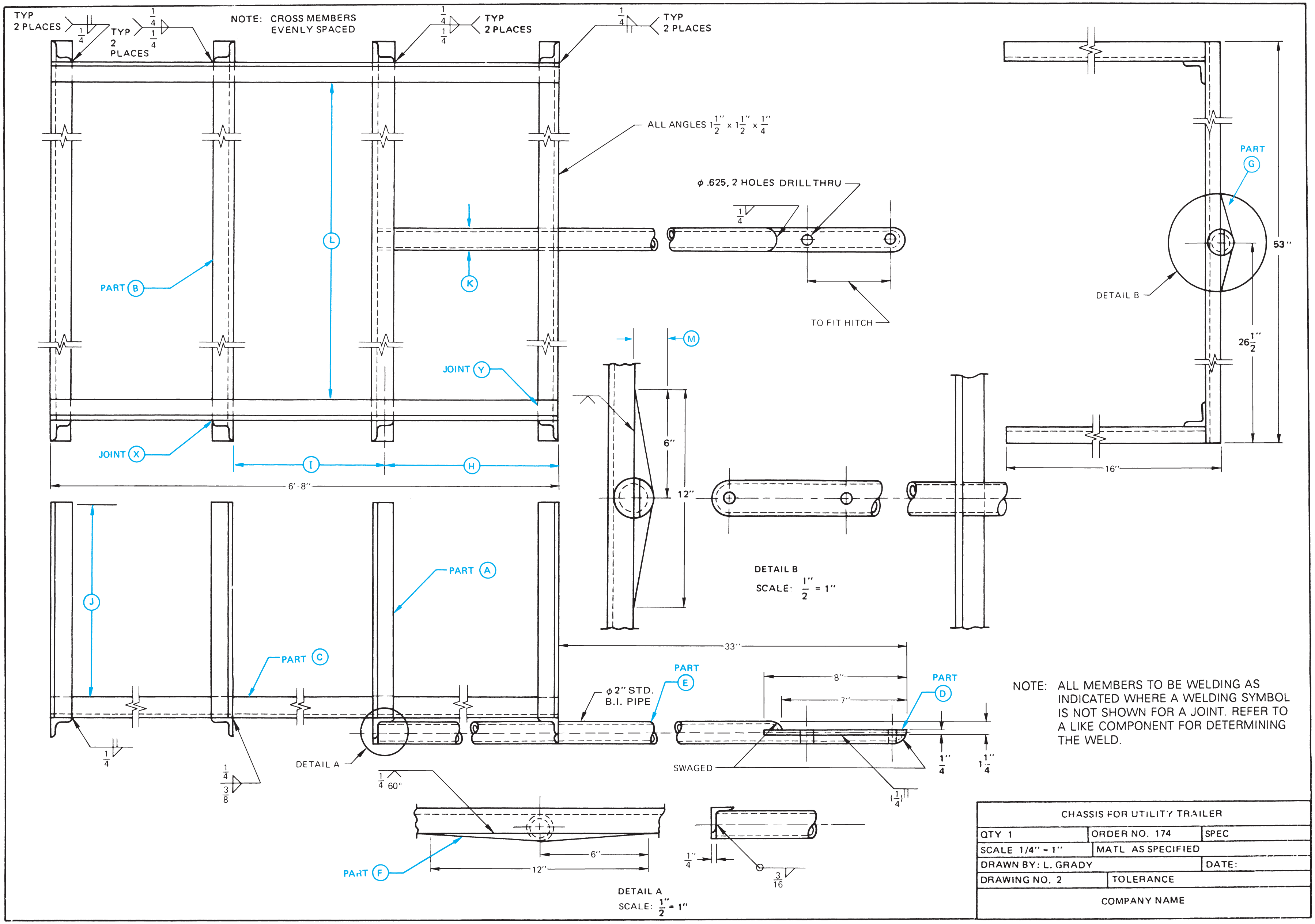
No.	Material	Size

20. What is the approximate combined length of all welds required on the tank? (Do not include welds on flanges, lugs, and studs.)

____

21. What does ∠ Ⓧ measure in degrees?

____



NOTE: ALL MEMBERS TO BE WELDING AS INDICATED WHERE A WELDING SYMBOL IS NOT SHOWN FOR A JOINT. REFER TO A LIKE COMPONENT FOR DETERMINING THE WELD.

CHASSIS FOR UTILITY TRAILER		
QTY 1	ORDER NO. 174	SPEC
SCALE 1/4" = 1"	MATL AS SPECIFIED	
DRAWN BY: L. GRADY		DATE:
DRAWING NO. 2	TOLERANCE	
COMPANY NAME		

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A LARGER DRAWING IS PROVIDED AT THE BACK OF THE TEXT.

SUMMARY REVIEW NO. 2B

Graph paper is provided at the end of this review for your use.

Refer to the drawing, Chassis for Utility Trailer, page 142.

1. Name the principal views used to show the object.

2. Why is this particular arrangement of views used?

3. What system of dimensioning is used?

4. List the structural metal shapes required for making the object.

5. Give the overall length sizes for the following parts:

Ⓐ ________ Ⓔ ________

Ⓑ ________ Ⓕ ________

Ⓒ ________ Ⓖ ________

Ⓓ ________

6. Give a reason for showing details A and B on the print.

7. What operation is performed on the end of the pipe that has been cut out?

8. Why are long break lines used on the principal views?

9. Sketch the kinds of break lines that are used.

10. Sketch a conventional break symbol that is used on the print.

11. Should this print be identified as an assembly, or should it be identified as a detail? Give an explanation for your answer.

12. Sketch the weld symbol that applies to joint Ⓨ.

13. Sketch the weld symbol that applies to joint Ⓧ.

14. What are the location dimensions for the drilled holes?

15. Why is the 6′–8″ dimension given in feet and inches rather than as 80″?

16. Give the dimensions for the following distances:

Ⓗ ________ Ⓚ ________

Ⓘ ________ Ⓛ ________

Ⓙ ________ Ⓜ ________

17. Give the diagonal dimension that can be used for checking the squareness of the rectangular frame. The check is to be made from its outer corners.

18. Sketch the different welding symbols shown on the print and give the significance of each.

19. What is the significance of the abbreviation “TYP”?

20. What material is specified for the pipe component of the chassis?

21. Identify the pipe component by letter.

22. a. How many detail drawings are shown on the print?

    b. Identify them by letter.

11 UNIT

Basic Joints for Weldment Fabrications

BASIC JOINTS

The basic joints used for weldment fabrications are: butt, corner, tee, lap, and edge, Figure 11.1. Combinations of these joints are also used.

For each type of joint, a number of different welds may be applied, Figure 11.1. The selection of the weld is based on a number of factors, including the thickness and kind of material to be welded, the

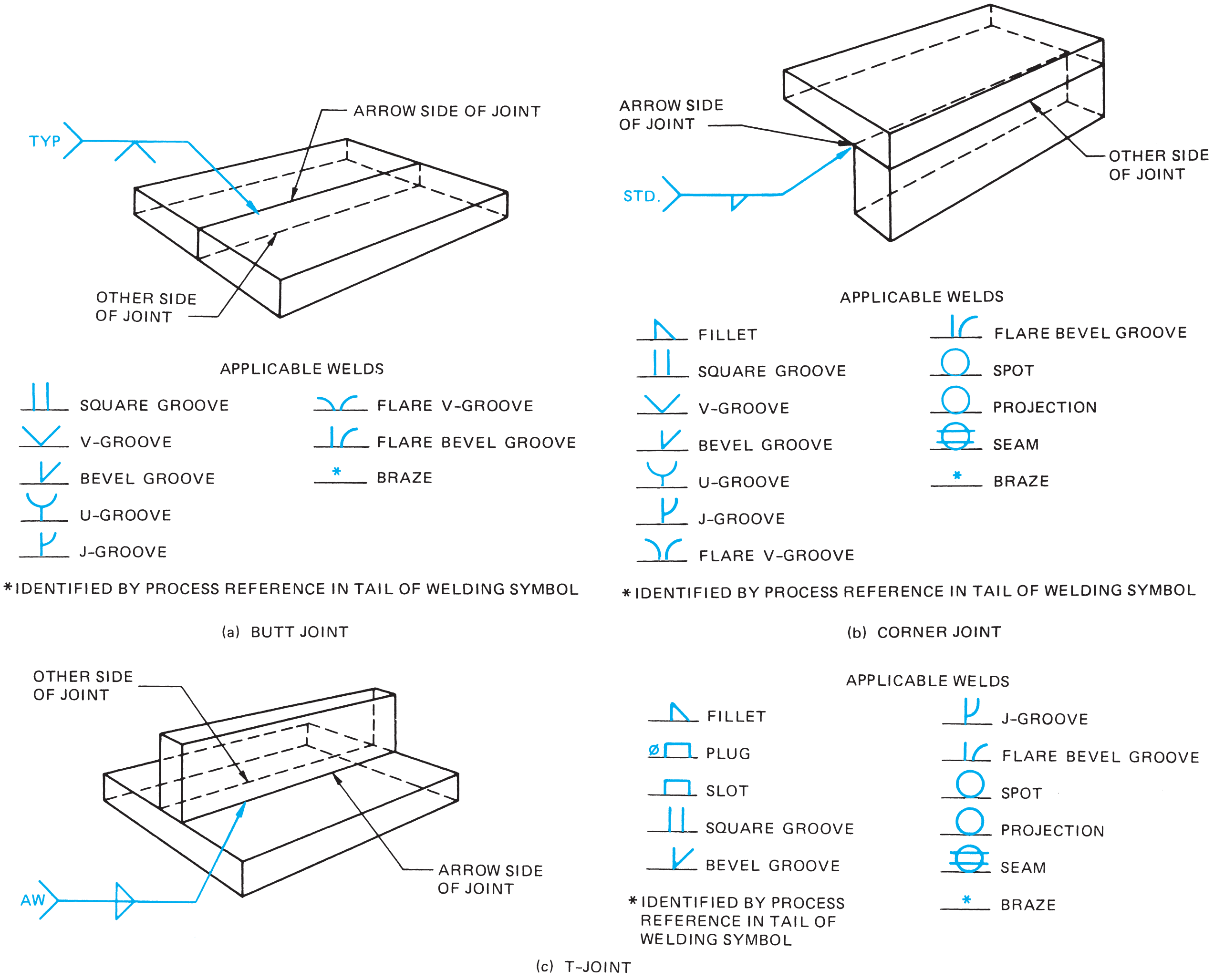
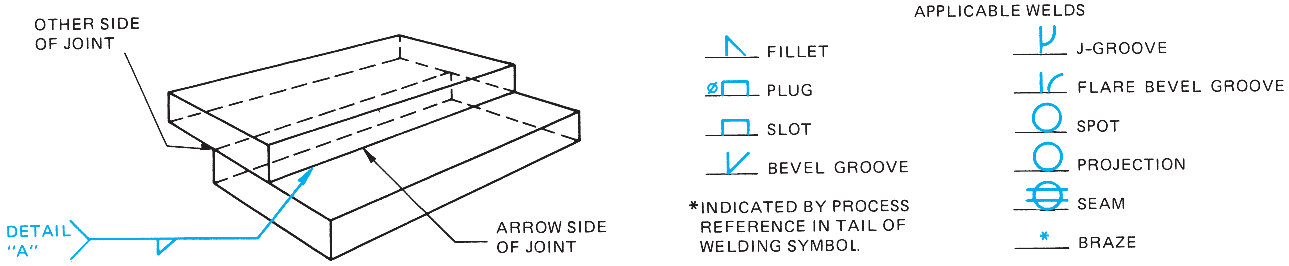
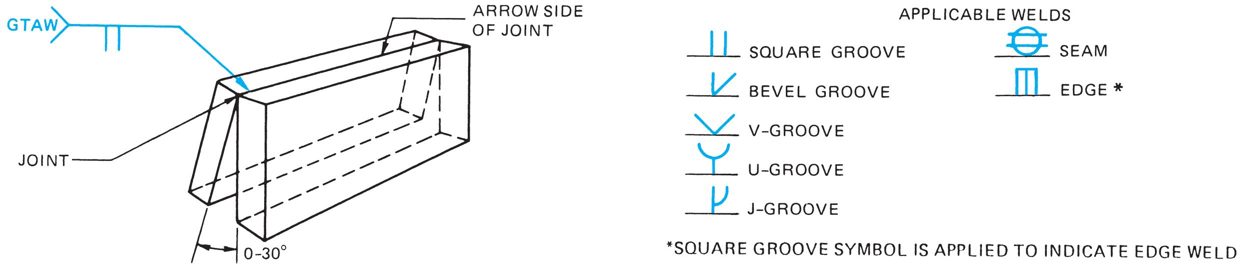


FIGURE 11.1 ■ Basic types of joints. (continued)



(d) LAP JOINT



(e) EDGE JOINT

FIGURE 11.1 ■ Basic types of joints. (concluded)

strength required, the kind of finish desired, and the location of the weld in terms of accessibility for making the weld. As shown in the figure, the weld symbol applied to each of the joints may have an arrow side, other side, or both sides significance. Note that metal shapes other than plate may be used in fabricating these joints, Figure 11.4.

The members of the joints to be welded may be formed to a particular shape in preparation for the weld, Figure 11.2(a) through Figure 11.2(d). This is done to increase the strength of the joint and to improve the appearance of the weldment.

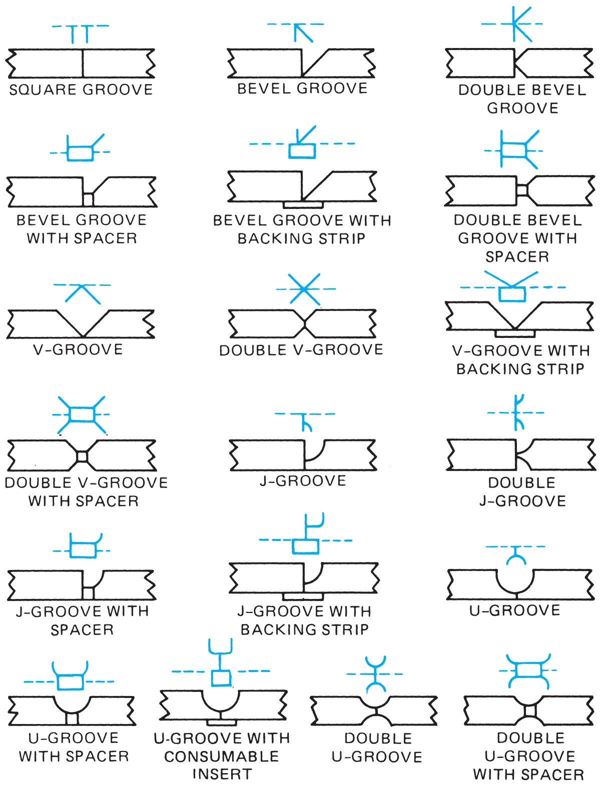
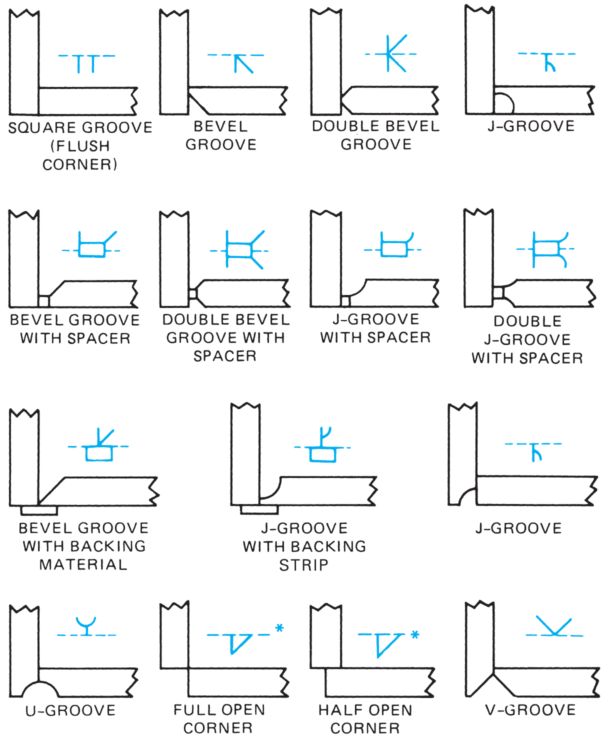

SQUARE GROOVE
BEVEL GROOVE
DOUBLE BEVEL GROOVE
BEVEL GROOVE WITH SPACER
BEVEL GROOVE WITH BACKING STRIP
DOUBLE BEVEL GROOVE WITH SPACER
V-GROOVE
DOUBLE V-GROOVE
V-GROOVE WITH BACKING STRIP
DOUBLE V-GROOVE WITH SPACER
J-GROOVE
DOUBLE J-GROOVE
J-GROOVE WITH SPACER
J-GROOVE WITH BACKING STRIP
U-GROOVE
U-GROOVE WITH SPACER
U-GROOVE WITH CONSUMABLE INSERT
DOUBLE U-GROOVE
DOUBLE U-GROOVE WITH SPACER

FIGURE 11.2(a) ■ Types of preparation for butt joints.


SQUARE GROOVE (FLUSH CORNER)
BEVEL GROOVE
DOUBLE BEVEL GROOVE
J-GROOVE
BEVEL GROOVE WITH SPACER
DOUBLE BEVEL GROOVE WITH SPACER
J-GROOVE WITH SPACER
DOUBLE J-GROOVE WITH SPACER
BEVEL GROOVE WITH BACKING MATERIAL
J-GROOVE WITH BACKING STRIP
J-GROOVE
U-GROOVE
FULL OPEN CORNER
HALF OPEN CORNER
V-GROOVE

*SYMBOL IS NOT USED TO DESCRIBE THE PREPARATION OF THESE JOINTS, BUT SYMBOL CAN BE USED TO DESCRIBE THE TYPE OF WELD

FIGURE 11.2(b) ■ Types of preparation for a corner joint.

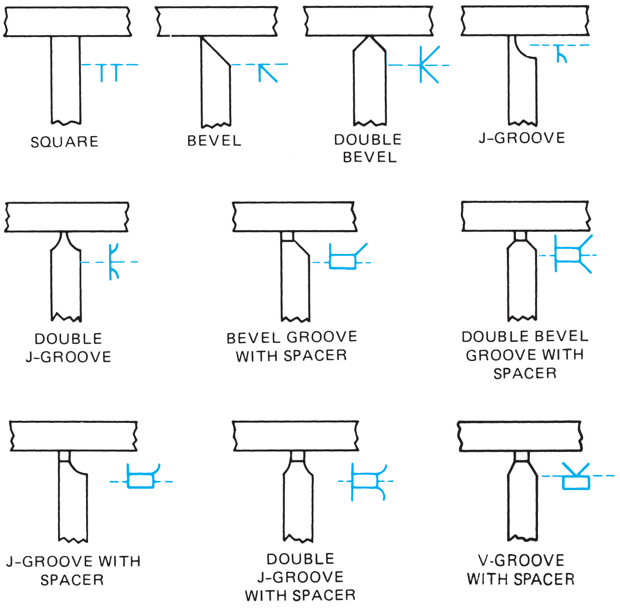


FIGURE 11.2(c) ■ Types of preparation for a T-joint.

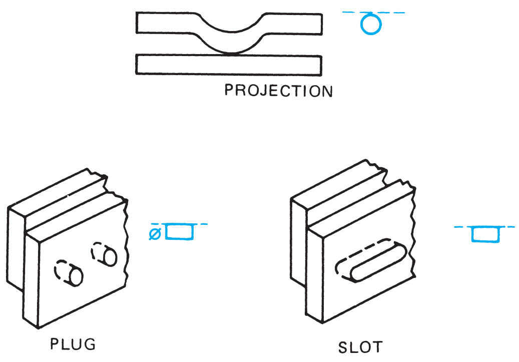


FIGURE 11.2(d) ■ Some types of preparation for a lap joint.

OTHER KINDS OF JOINTS

In addition to the basic joints, there is an assortment of other joints for special purposes, Figure 11.3. Corner flange and edge flange joints are used for light metals. The flare bevel and flare V-groove joints are used in weldments of heavier gage materials where one or two of the members have a curved shape. The scarf joint is used for brazed weldments.

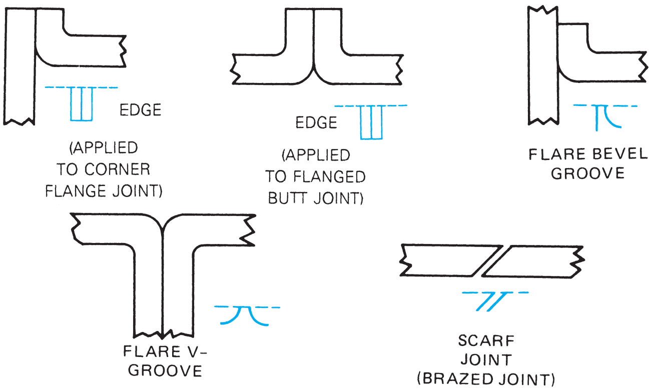
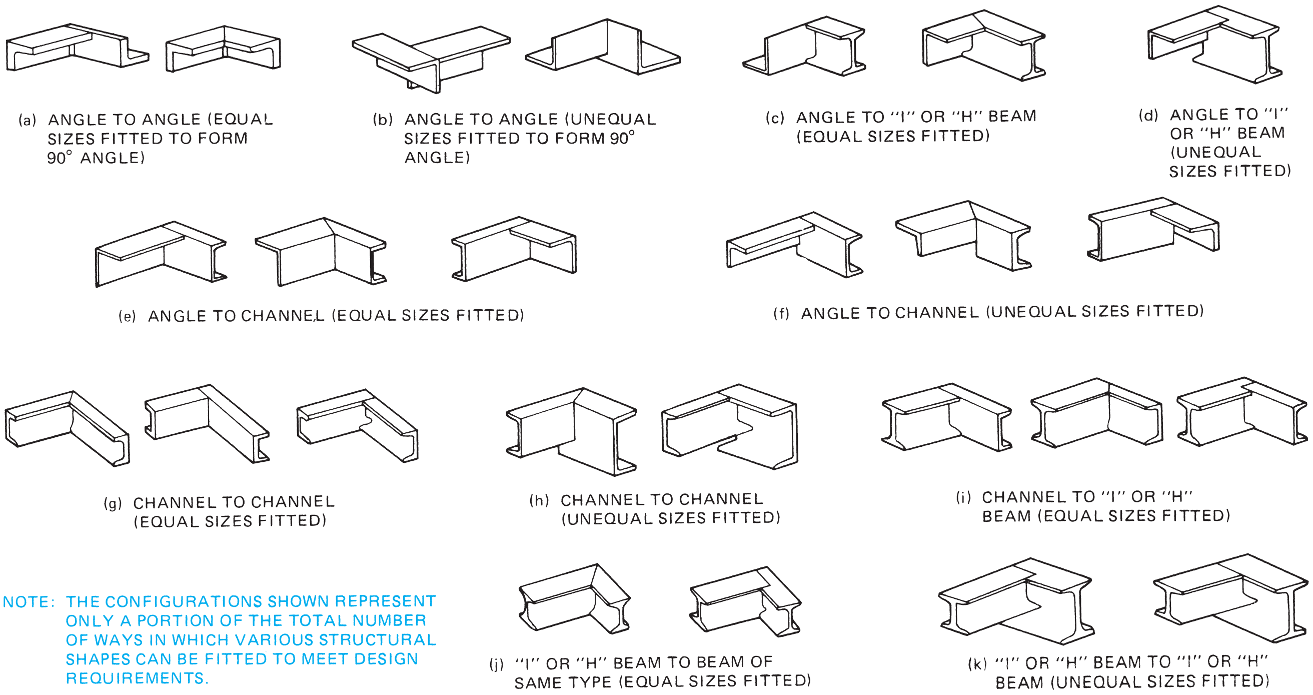

EDGE
(APPLIED TO CORNER FLANGE JOINT)
EDGE
(APPLIED TO FLANGED BUTT JOINT)
FLARE BEVEL GROOVE
FLARE V-GROOVE
SCARF JOINT (BRAZED JOINT)

FIGURE 11.3 ■ Other types of joints.

JOINTS COMMONLY USED WITH STRUCTURAL SHAPES

Many methods can be used to assemble structural members to form a joint. There are also many different weld and groove designs that may be used with these structural members. The design of the weld and/or the groove is usually the function of the designer. Standard welding symbols are used to indicate the welds required. Weldments may be fabricated using only one type of structural shape or combinations of different structural shapes. Figure 11.4 illustrates a few methods of joining similar and dissimilar structural shapes.



(a) ANGLE TO ANGLE (EQUAL SIZES FITTED TO FORM 90° ANGLE)

(b) ANGLE TO ANGLE (UNEQUAL SIZES FITTED TO FORM 90° ANGLE)

(c) ANGLE TO "I" OR "H" BEAM (EQUAL SIZES FITTED)

(d) ANGLE TO "I" OR "H" BEAM (UNEQUAL SIZES FITTED)

(e) ANGLE TO CHANNEL (EQUAL SIZES FITTED)

(f) ANGLE TO CHANNEL (UNEQUAL SIZES FITTED)

(g) CHANNEL TO CHANNEL (EQUAL SIZES FITTED)

(h) CHANNEL TO CHANNEL (UNEQUAL SIZES FITTED)

(i) CHANNEL TO "I" OR "H" BEAM (EQUAL SIZES FITTED)

NOTE: THE CONFIGURATIONS SHOWN REPRESENT ONLY A PORTION OF THE TOTAL NUMBER OF WAYS IN WHICH VARIOUS STRUCTURAL SHAPES CAN BE FITTED TO MEET DESIGN REQUIREMENTS.

(j) "I" OR "H" BEAM TO BEAM OF SAME TYPE (EQUAL SIZES FITTED)

(k) "I" OR "H" BEAM TO "I" OR "H" BEAM (UNEQUAL SIZES FITTED)

FIGURE 11.4 ■ Joining of similar and dissimilar structural shapes.

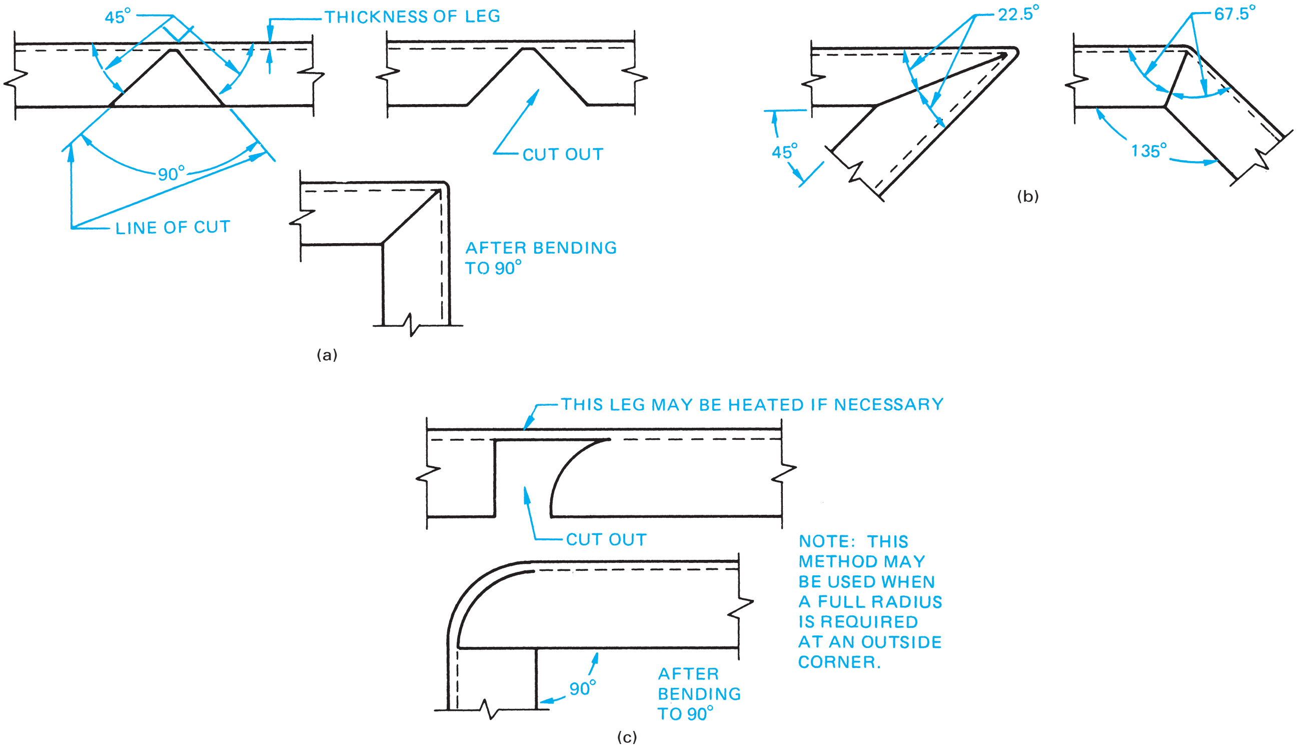

45°
THICKNESS OF LEG
90°
LINE OF CUT
CUT OUT
AFTER BENDING TO 90°
(a)
22.5°
45°
67.5°
135°
(b)
THIS LEG MAY BE HEATED IF NECESSARY
CUT OUT
NOTE: THIS METHOD MAY BE USED WHEN A FULL RADIUS IS REQUIRED AT AN OUTSIDE CORNER.
90°
AFTER BENDING TO 90°
(c)

FIGURE 11.5 ■ Fabricating joints by cutting and bending.

Joints for structural shapes may also be formed by cutting and bending the members, Figure 11.5. In certain cases, this procedure may be more economical, since less cutting and welding are required. Although the examples shown are for an angle bar, the same principles apply to other structural shapes.

When a grooved joint is required on heavy structural shapes, it may be possible to provide for a groove without formal preparation of the joint members. The angle and T-bar joints shown in Figure 11.6 illustrate this point.

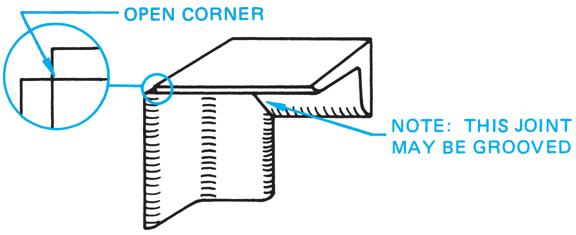


FIGURE 11.6(a) ■ Forming a joint with angles. There is no formal preparation of either member.

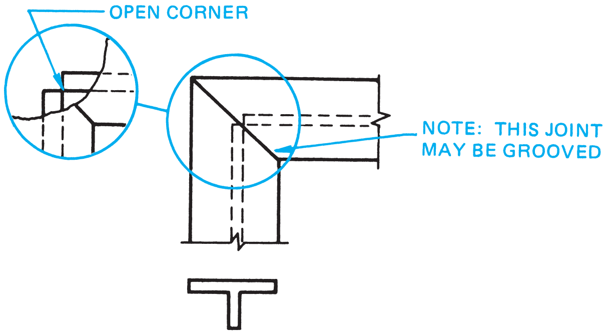


FIGURE 11.6(b) ■ Forming a joint with T-bars. There is no formal preparation of either member.

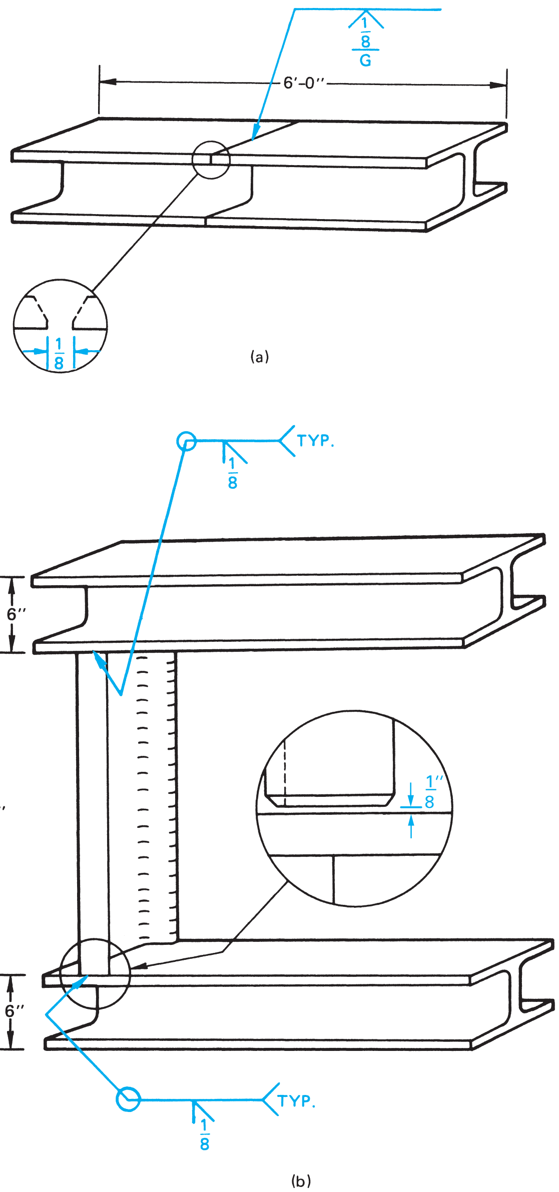


FIGURE 11.7(a, b) ■ Forming bevel groove joints.

JOINT FITUP

The design of the structure may require a joint spacing or root opening (gap) between members being welded. This is indicated by welding symbols or notes on the print. Spacing as required must ensure that the overall dimensions are maintained. For example, consider the joining of two lengths of structural shapes with a ⅛″ root opening to provide a specific overall length, as illustrated in Figure 11.7. In Figure 11.7(a), the 6-foot dimension must be maintained. Thus, the combined lengths of both members must be 6 feet minus ⅛″, or 5′–11⅞″ to give a finished length of 6 feet. In Figure 11.7(b), a bevel groove joint is required at the top and bottom of the channel. The length of channel required is 5′-8″ minus the combined size of the "H" beams located at the top and bottom, minus the root gap dimension required at the top and bottom. Therefore, the length of channel required is:

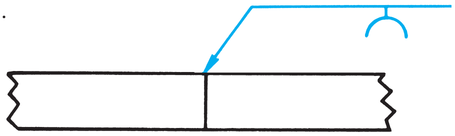
5′-8″ − 12″ = 4′-8″ − ¼″ = 4′-7¾″

UNIT 11: REVIEW

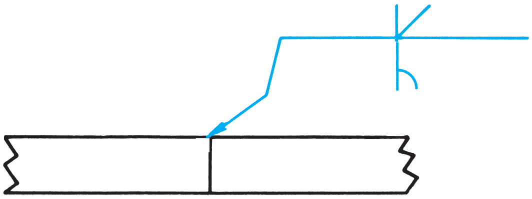
Graph paper is provided at the end of this review for your use.

1. Sketch the joint preparation indicated by the following welding symbols:

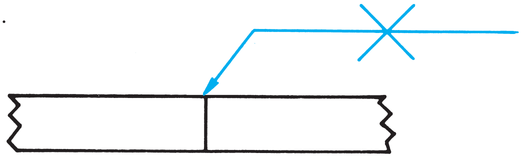
a.



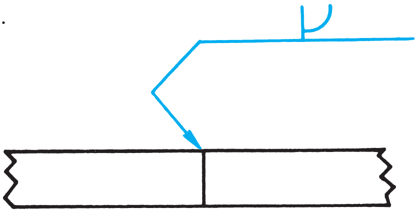
b.



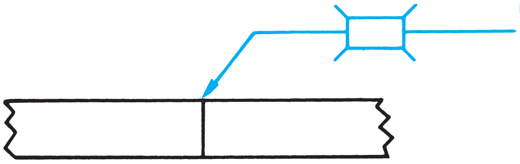
c.



d.

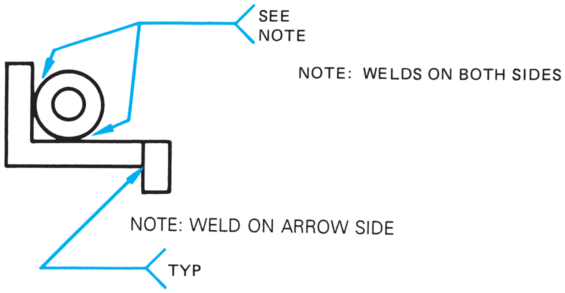


e.

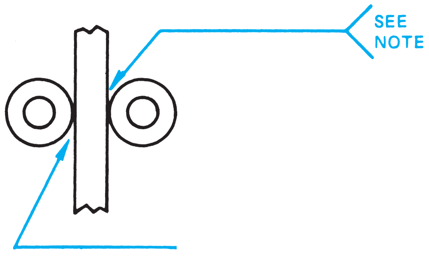


2. a. Add an appropriate weld symbol to each of the following sketches. All members are heavy-gage metal. Assume that there is no joint preparation other than what is shown on each sketch.

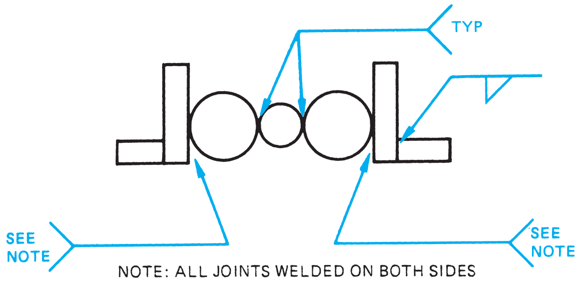
   b. Identify each weld symbol used.



(3) ____________________



(4) ____________________



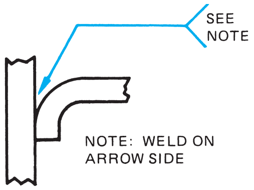
(5) ____

____

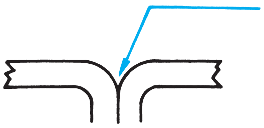
____

____

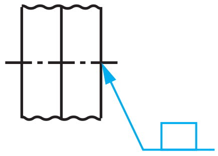
____



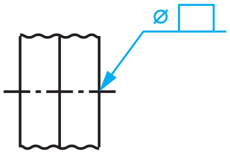
(1) ____________________



(2) ____________________



(6) ____________________

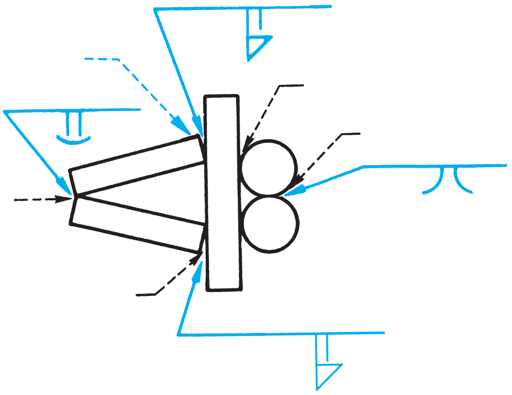


____

3. a. Identify the joints shown in the following sketch by placing the identification next to the arrowhead.

   b. Identify the weld(s) that would be applied to each joint. List the joint, then the applicable weld(s).

a.

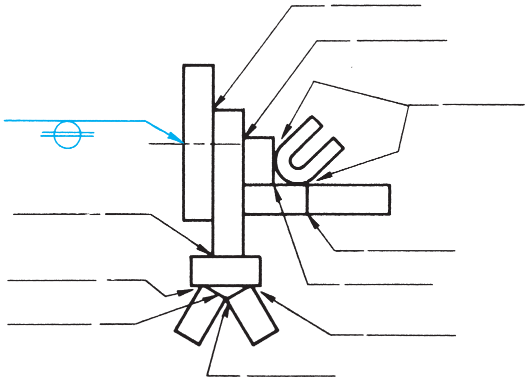


b.

4. a. Identify the joints formed in the assembly of the following structural shapes.

   b. Explain the significance of the welding symbol shown.

a.

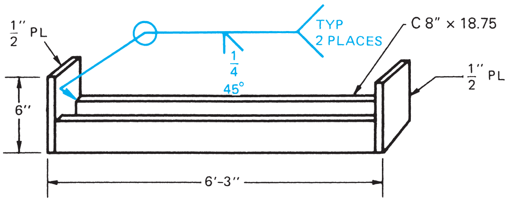


b.

5. a. What is the length of the channel that is required in fabricating the following assembly?

   b. Prepare a three-view orthographic sketch with dimensions (top, front, and right side views) of the assembly.

   c. Include a detailed drawing to show the joint preparation required.



   d. What is the significance of the break in the welding symbol arrow line?

   e. What is the significance of the letter "C" in the dimension C" × 18.75?

12 UNIT

Fillet Welds

The **fillet weld**, identified by the symbol ◺, is one of the most widely used types of welds. This symbol is always drawn so that the vertical leg is to the reader's left, Figure 12.1.

SIZE OF THE LEGS

The size of a fillet weld refers to the length of the legs of the weld. The two legs are assumed to be equal in size unless otherwise specified. This size is shown to the left of the weld symbol, Figure 12.2. If a fillet is shown on both sides of the joint, it is identified as a double fillet weld. The size of the legs is indicated for each fillet weld as shown in Figure 12.3 and Figure 12.4.

Fillet welds may have unequal legs. In this case, the size of each leg is indicated in parentheses at the left of the weld symbol, Figure 12.5. Since the symbol does not specify which dimension belongs to which leg, this information must be detailed on the drawing.

When a general note covers the size of fillet welds, the dimension does not usually appear on the welding symbol. An example of a note of this type is: "Unless otherwise indicated, all fillet welds are 3⁄16″ in size."

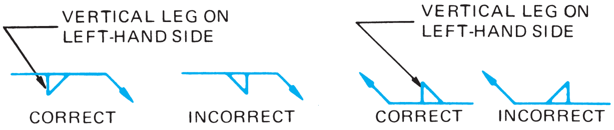

VERTICAL LEG ON LEFT-HAND SIDE
CORRECT
INCORRECT
VERTICAL LEG ON LEFT-HAND SIDE
CORRECT
INCORRECT

FIGURE 12.1 ■ Fillet weld symbol.

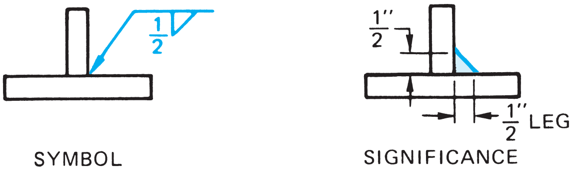


FIGURE 12.2 ■ Fillet weld size.

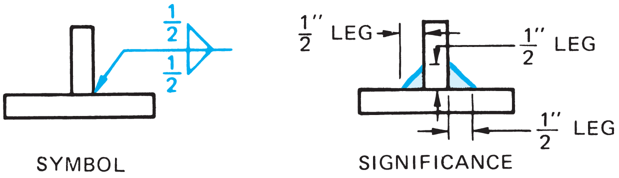


FIGURE 12.3 ■ Double fillet weld.

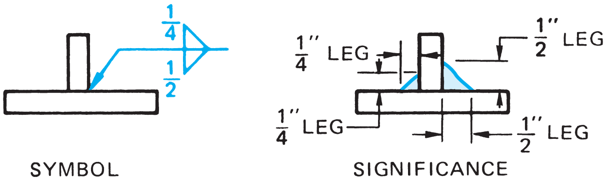


FIGURE 12.4 ■ Double fillet welds of different sizes.

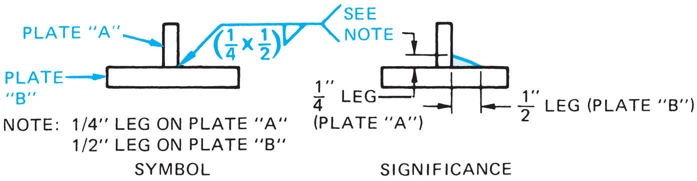


FIGURE 12.5 ■ Fillet welds with unequal legs.

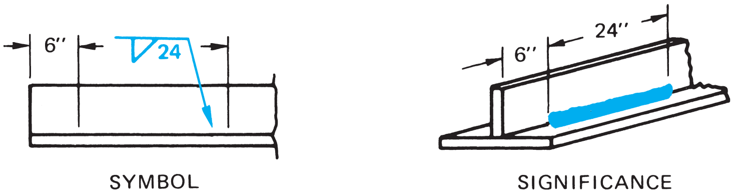


FIGURE 12.6 ■ Length of fillet weld.

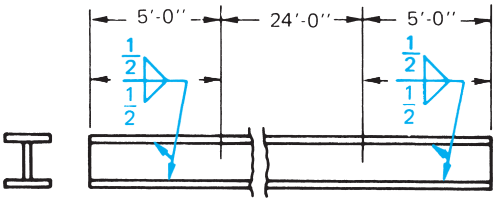


FIGURE 12.7 ■ Length of fillet weld specified by standard dimensioning practice.

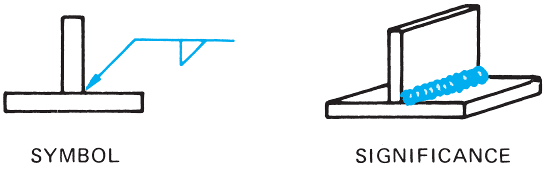


FIGURE 12.8 ■ Continuous fillet weld.

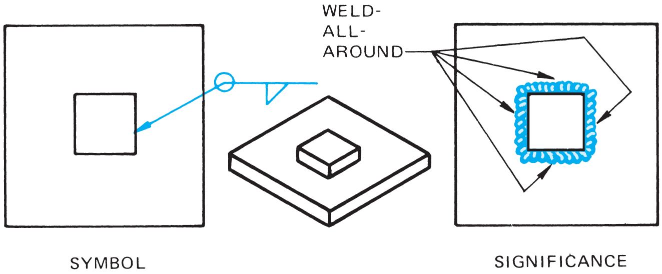


FIGURE 12.9 ■ Weld-all-around symbol.

LENGTH OF FILLET WELDS

If the length of the weld is specified, it is placed on the immediate right of the weld symbol, Figure 12.6.

In addition, specific lengths of fillet welds can be described by placing the symbols in conjunction with the dimension lines of the drawing, Figure 12.7. Note that continuous welds are called for in each of the 5′-0″ dimensions.

When a length is not specified on the welding symbol, the fillet weld is assumed to be continuous, Figure 12.8.

In a similar manner, when the weld-all-around symbol is used, a length dimension is not needed, Figure 12.9.

DETERMINING THE EXTENT OF WELDING

When fillet welds are not welded all around, or are not continuous, the extent of the welding can be shown by one of two methods. The first method shows the extent of welding graphically by the use of section lining, or some other similar definite indication, Figure 12.10. Extension lines are used as terminal points for the section lining; dimension lines with dimensions are included.

A second method makes use of multiple arrows to point out the sections to be welded. An arrow for each section is applied, Figure 12.11. In this case, dimensions are not used. It is assumed that each section is welded to the extent that it touches the other member of the joint. This method is used principally when it is awkward to dimension the drawing.

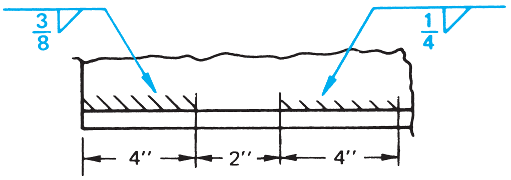


FIGURE 12.10 ■ Section lining denoting the extent of the welds.

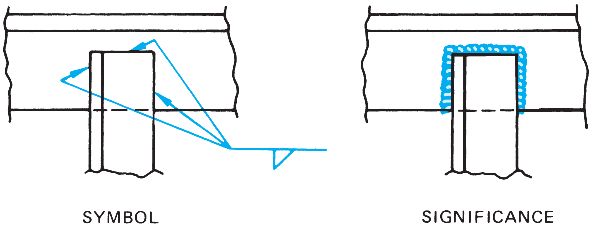


FIGURE 12.11 ■ Using multiple arrows to indicate the extent of welds.

PITCH AND INTERMITTENT WELDING

Intermittent welding consists of a series of short welds. Each short weld is called an **increment** (represents length of weld). The center-to-center distance, in inches or millimeters of each increment, is the **pitch.** The pitch is shown on the welding symbol to the immediate right of the length of increment dimension, Figure 12.12. Note that if additional welds are required at the ends of the joint, they are specified by separate symbols and dimensions. Otherwise, the unwelded length should not exceed that length specified by the symbol.

Chain intermittent welding means that the welds appear directly opposite each other on the two sides of the joint, Figure 12.13. Staggered intermittent welds are those that are not directly opposite one another, Figure 12.14. Notice that when the welds are staggered, the welding symbols above and below the reference line are not aligned with each other.

Continuous and chain or staggered intermittent welding are often used together in a weldment, Figure 12.15.

When making such a combination, weld space should be left between the end of the continuous weld and the beginning of the first intermittent weld. This space is equal to the pitch minus the length of one increment. Therefore, in Figure 12.15, the space equals 5″ minus 2″ = 3″.

The length of the increment is extended to terminate the weld at the end of the joint when the length of the joint extends beyond the specified length of the increment. The same applies to staggered intermittent welds.

Note the 4″ dimension between the continuous weld and the center of the first intermittent weld. This dimension minus half of the length of the first 2″ increment (or 1″) gives the 3″ space previously determined.

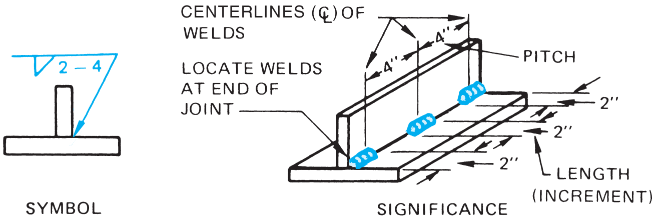


FIGURE 12.12 ■ Length and pitch of increments of intermittent welding.

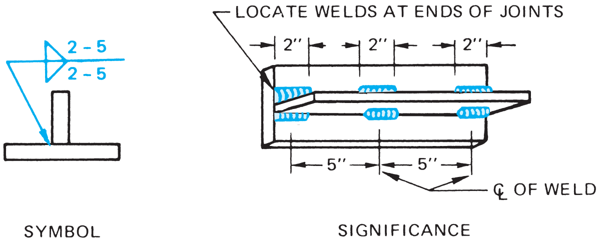


FIGURE 12.13 ■ Chain intermittent welding.

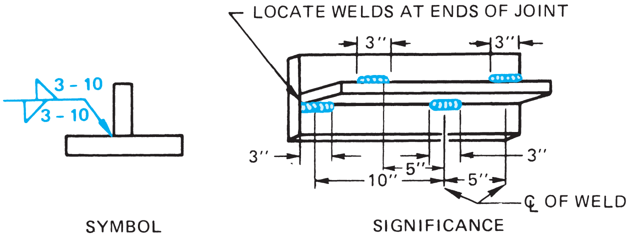


FIGURE 12.14 ■ Staggered intermittent welding symmetrically spaced (unless otherwise noted).

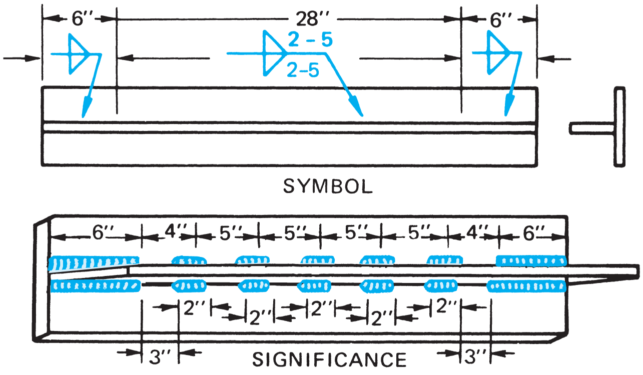


FIGURE 12.15 ■ Combined chain intermittent and continuous welding.

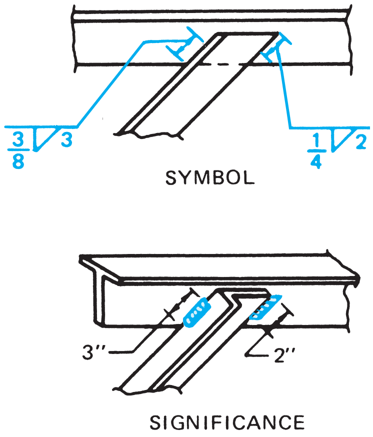


FIGURE 12.16 ■ Use of extension and dimension lines to locate and specify length of welds.

Extension and dimension lines are occasionally used with the welding symbol to locate the desired welds, Figure 12.16. Note that the arrows of the welding symbols point to the dimension lines rather than to surfaces.

CONTOUR AND FINISHING

Finish and contour indications are added to the weld symbols as required, Figure 12.17.

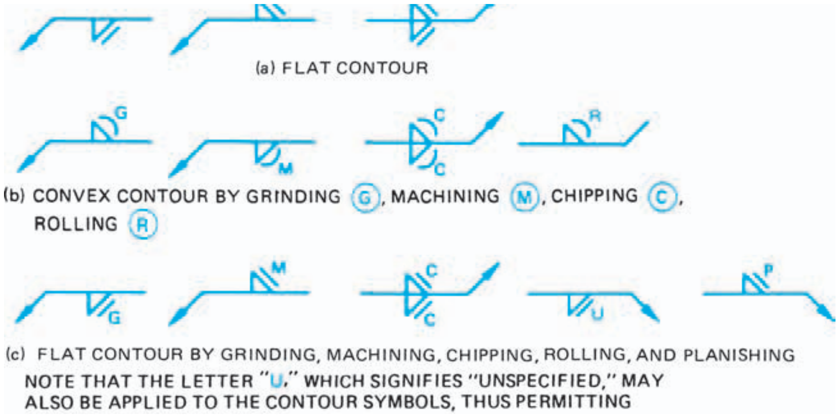

(a) FLAT CONTOUR
G
M
C
C
R
(b) CONVEX CONTOUR BY GRINDING (G), MACHINING (M), CHIPPING (C),
ROLLING (R)
G
M
C
C
U
P
(c) FLAT CONTOUR BY GRINDING, MACHINING, CHIPPING, ROLLING, AND PLANISHING
NOTE THAT THE LETTER "U," WHICH SIGNIFIES "UNSPECIFIED," MAY
ALSO BE APPLIED TO THE CONTOUR SYMBOLS, THUS PERMITTING

FIGURE 12.17 ■ Finish and contour specifications on filletweld symbol.

USE OF FILLET WELD IN COMBINATION WITH OTHER SYMBOLS

The fillet weld symbol may be used in combination with other symbols, Figure 12.18. This is also true of many of the other weld symbols. Figure 12.18(a) shows the application of the fillet weld on the opposite (other) side of a square groove weld. Figure 12.18(b) shows the application of a fillet weld on the same side following the completion of a square groove weld.

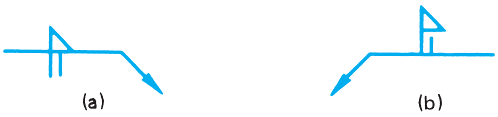
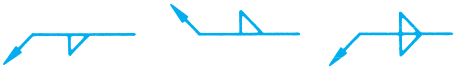


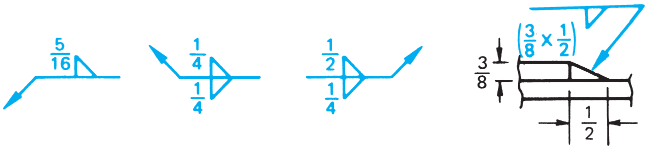
FIGURE 12.18(a, b) ■ Use of the fillet weld symbol in combination with other symbols.

In summary, the fillet weld symbol may include:

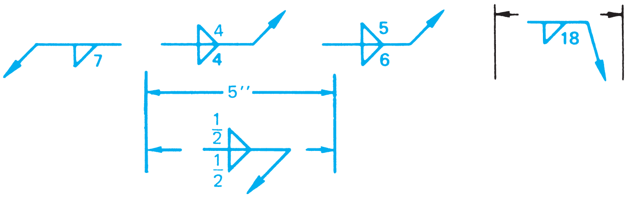
a. Arrow side, other side, or both sides indication



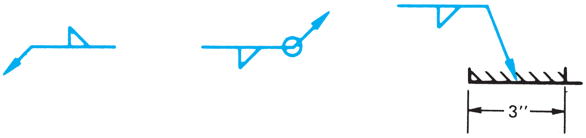
b. Size of legs



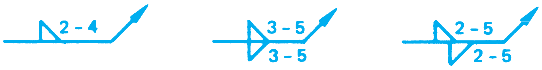
c. Length of weld



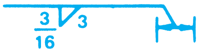
d. Extent of weld

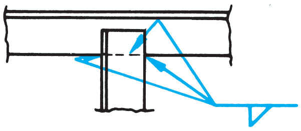


e. Increment of welds and pitch



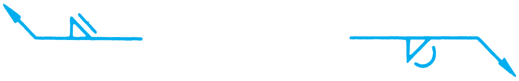
f. Location of weld



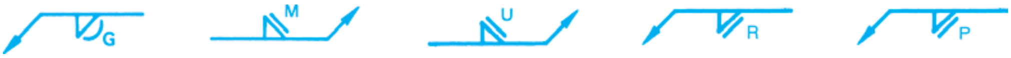


(WELDS ARE LOCATED ALONG THE ENTIRE JOINT)

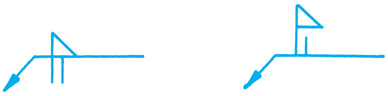
g. Contour



h. Contour and finish. Finish may be unspecified by using the letter “U”.



i. Other symbols in combination with the fillet weld symbol

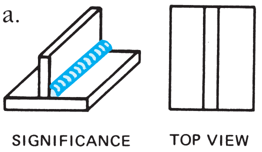


UNIT 12: REVIEW A

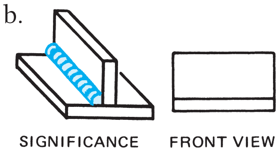
Graph paper is provided at the end of this review for your use.

1. Apply the appropriate welding symbol(s) to each of the orthographic views to indicate the welds shown in the pictorial representations (a) through (d).

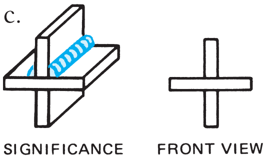
a.



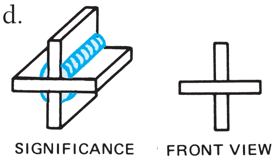
b.



c.

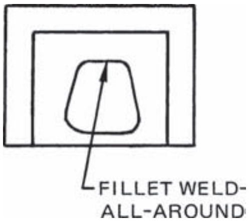


d.



2. When is the size of fillet welds not included in the welding symbol?

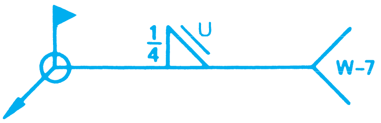
3. Sketch a symbol that indicates the following weld.



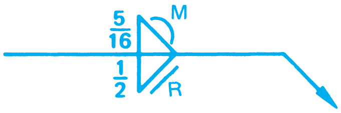
4. Give two situations when the length is not dimensioned on the welding symbol.

5. List all information given in the following symbols:

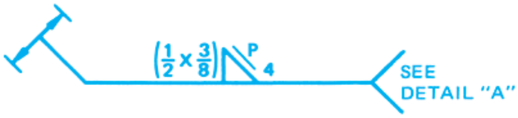
a.



b.



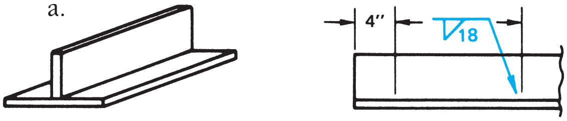
c.



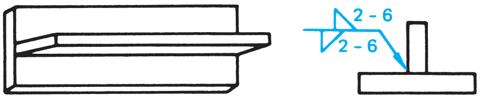
6. Why are fillet welds with unequal legs detailed?

7. Refer to the orthographic drawings (a) through (d). Sketch and dimension the welds required on the pictorial drawings shown with each.

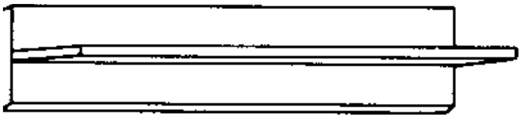
a.



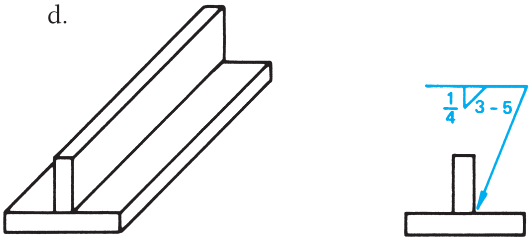
b.



c.



d.

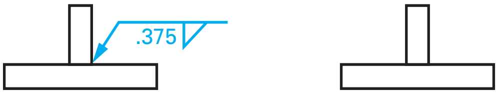


8. Sketch how the weld would appear as specified in question 7a. Use a top view to illustrate this.

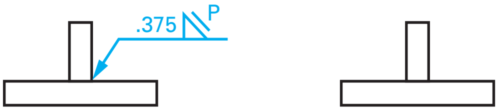
9. Sketch how the welds would appear as specified in question 7c. Use a top view to illustrate this.

10. Refer to illustrations (a) through (g) as follow and complete how the weld would appear in the adjacent illustrations. Include dimensions.

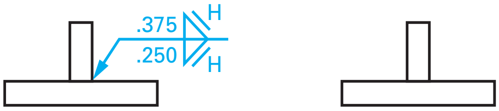
a.



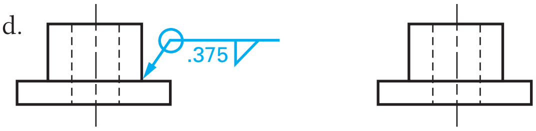
b.



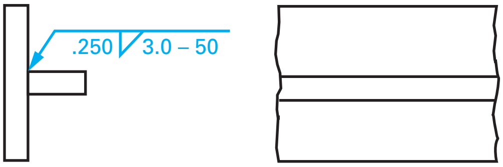
c.



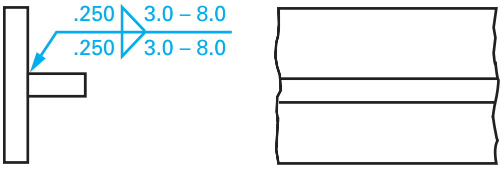
d.



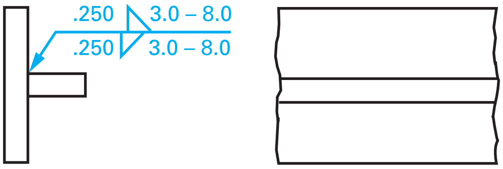
e.



f.



g.



UNIT 12: REVIEW B

Refer to the drawing, Bracket, below.

1. Explain fully the meaning of each of the welding symbols used on the drawing.

   Ⓐ

   Ⓑ

   Ⓒ

   Ⓓ

   Ⓔ

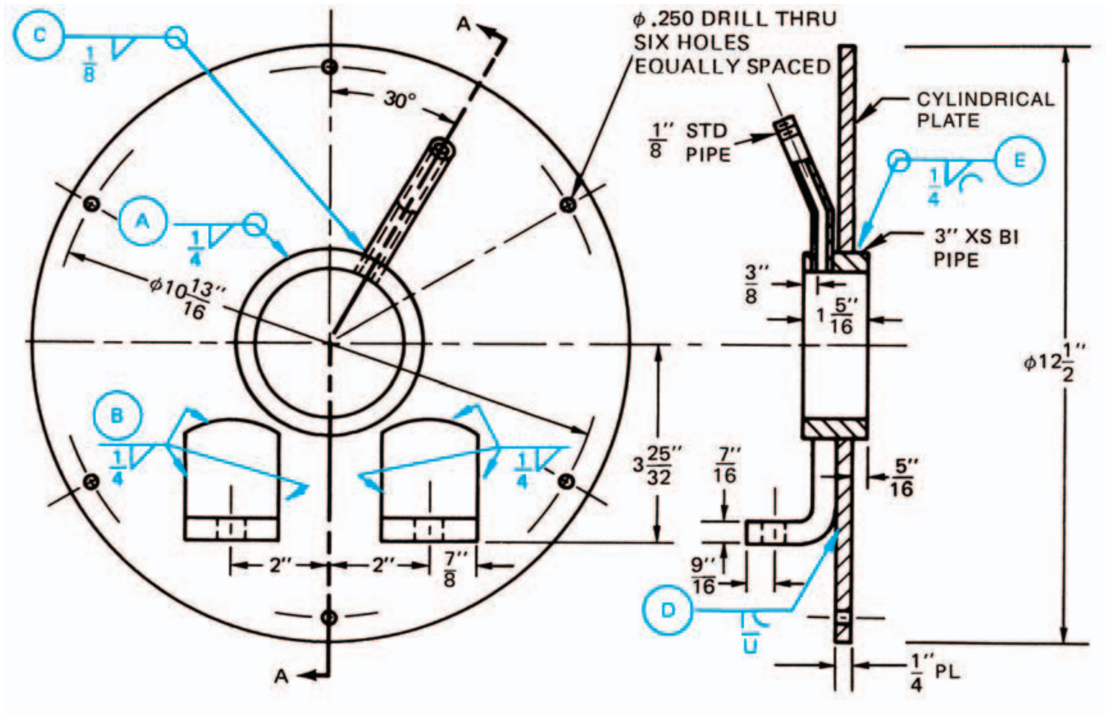
2. How far apart (in degrees) are the equally spaced drilled holes?

3. Interpret the dimension 3" XS BI Pipe.

4. How many parts does this bracket consist of?

5. What plate size is used?

6. What type of section is represented by section A-A?



BRACKET

7. Why is this particular section shown?

____

8. a. How is the 3" pipe fastened to the cylindrical plate?

____

b. How is the ⅛" pipe fastened to the 3" pipe?

____

9. What is the significance of “six holes ES”?

____

____

10. In what order should this bracket be assembled and welded? Give reason(s) for the order selected.

____

____

____

____

____

____

____

____

____

11. How many drilled holes will these parts contain before welding is performed?

____

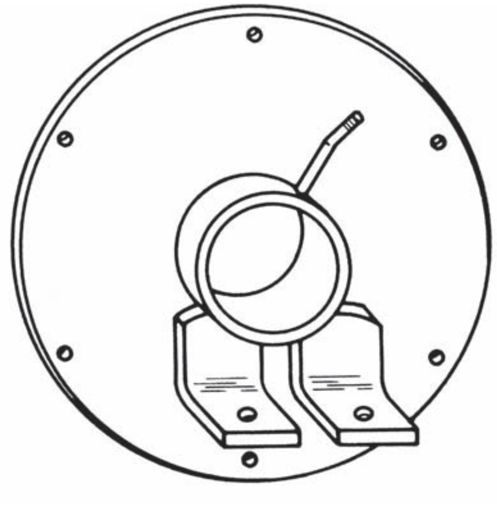
12. What hole size is required for the ⅛″ std. pipe? (Refer to Appendix 4.)

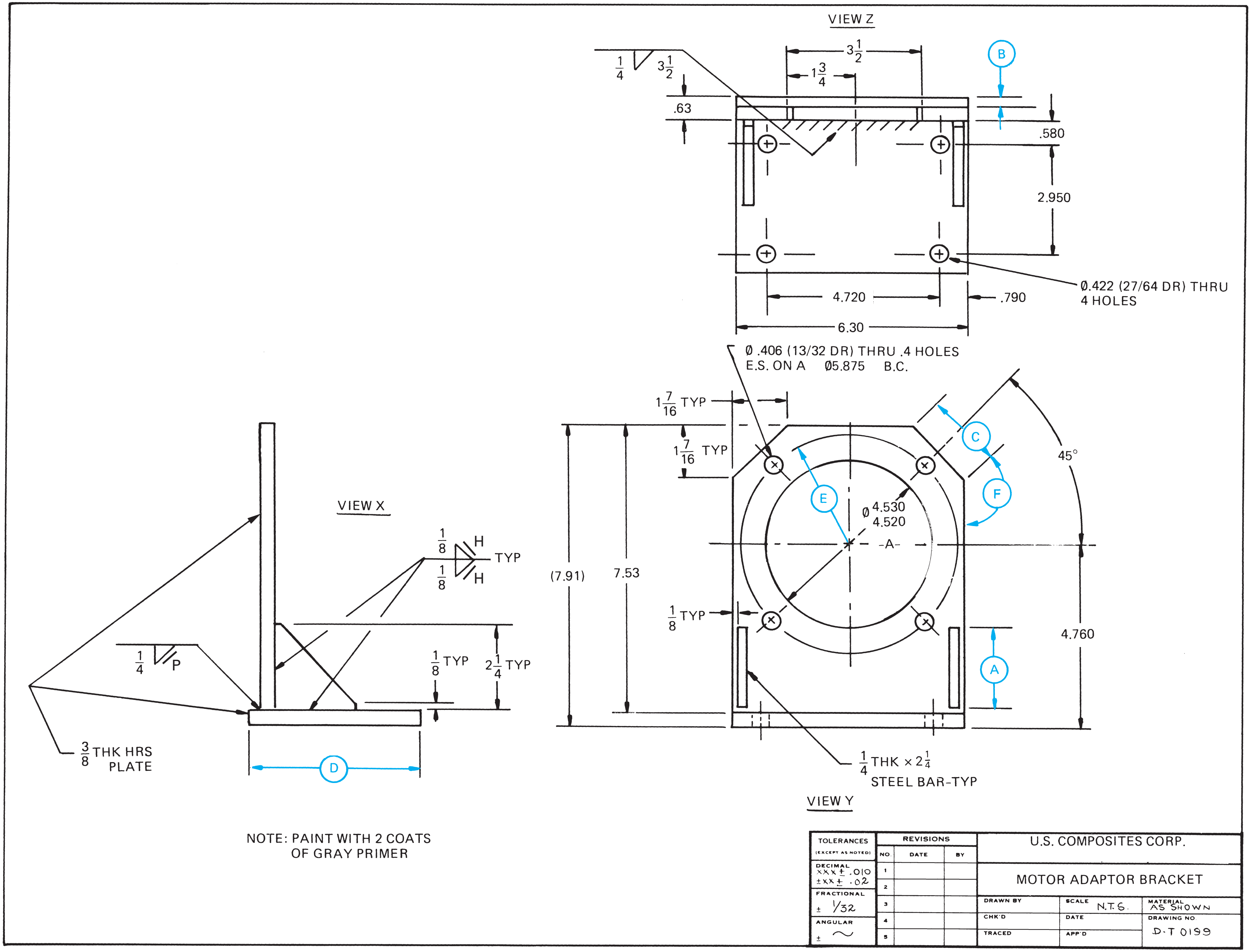
____

13. What hole size(s) are missing on the drawing?

____

14. On the pictorial drawing below, show the welds called for on the drawing and identify each weld.




VIEW Z
$3\frac{1}{2}$
$1\frac{3}{4}$
$\frac{1}{4}$
$3\frac{1}{2}$
.63
B
.580
2.950
Ø.422 (27/64 DR) THRU
4 HOLES
4.720
.790
6.30
Ø .406 (13/32 DR) THRU .4 HOLES
E.S. ON A Ø5.875 B.C.
$1\frac{7}{16}$ TYP
$1\frac{7}{16}$ TYP
C
45°
F
E
Ø 4.530
4.520
-A-
(7.91)
7.53
$\frac{1}{8}$ TYP
4.760
A
$\frac{1}{4}$ THK × $2\frac{1}{4}$
STEEL BAR–TYP
VIEW Y
VIEW X
$\frac{1}{8}$ H
TYP
$\frac{1}{8}$ H
$\frac{1}{4}$ P
$\frac{1}{8}$ TYP
$2\frac{1}{4}$ TYP
$\frac{3}{8}$ THK HRS
PLATE
D
NOTE: PAINT WITH 2 COATS
OF GRAY PRIMER
TOLERANCES
(EXCEPT AS NOTED)
DECIMAL
.XXX ± .010
±.XX ± .02
FRACTIONAL
± 1/32
ANGULAR
± ~
REVISIONS
NO.
DATE
BY
1
2
3
4
5
U.S. COMPOSITES CORP.
MOTOR ADAPTOR BRACKET
DRAWN BY
SCALE N.T.S.
MATERIAL AS SHOWN
CHK'D
DATE
DRAWING NO.
D-T 0199
TRACED
APP'D

UNIT 12: REVIEW C

Refer to the drawing, Motor Adaptor Bracket, page 166.

1. What is the spacing of the holes on the B.C.?

2. Identify the views shown on the drawing.

3. What is the significance of the $\genfrac{}{}{0pt}{}{4.530}{4.520}$ diameter dimension?

4. a. Note that view Y is incomplete. Sketch in the line(s) that are missing.
   b. Identify the types of line(s) that are missing.

5. View X is incomplete. Sketch in the lines that are missing. What do these lines represent?

6. View Z is incomplete. Sketch in the missing lines. What do these lines represent?

7. What element is missing in the both sides welding symbol shown in view X?

8. How many separate welds are to be made as indicated in view X?

9. What kind and size welds are to be used for welding the ¼″ × 2¼″ steel bars?

10. How many inches of weld are indicated by the welding symbol shown in view Z?

11. How many inches of weld are indicated by the symbol shown in view X?

12. a. How many reference dimensions are shown on the drawing?
    b. Give the purpose of a reference dimension.

13. List a general note found on the drawing.

14. a. What is the maximum allowable size for dimension 7.53?
    b. What is the minimum allowable size?

15. a. What is the maximum allowable size for dimension 1⁷⁄₁₆″?
    b. What is the minimum allowable size?

16. a. What is the maximum allowable size for dimension 4.760?
    b. What is the minimum allowable size?

17. What do the dimensions 3½ and 1¾ represent?

18. What is the significance of the sectioning shown in view Z?

____

____

____

19. How many drilled holes are required?

____

20. What is the angle dimension for Ⓕ?

____

21. Give the dimensions for the following:

Ⓐ ______________________________

Ⓑ ______________________________

Ⓒ ______________________________

Ⓓ ______________________________

Ⓔ ______________________________

22. Prepare a bill of materials for the Motor Adaptor Bracket.

Bill of Materials

No.	Material	Size

23. a. What surface finishes are specified for the welds in view X?

____

b. What methods of finish are specified to make these finishes?

____

24. a. List the location dimensions for the drilled holes shown in view Z.

____

b. How deep are the holes to be drilled?

____

UNIT 13

Groove Welds

GROOVE WELD

The eight types of groove welds are shown by symbols that indicate how the members are to be prepared and welded, Figure 13.1. In the J- and bevel groove welds, only one of the two members is chamfered or beveled. To indicate the member to be prepared for these welds, the arrow breaks toward that member, Figure 13.2(a) and Figure 13.2(b).

The weld symbol is placed on the reference line in accordance with the usual arrow side, other side significance.

DEPTH OF GROOVE PREPARATION

The dimension for the depth of the groove is placed to the immediate left of the weld symbol, and on the same side of the reference line as the symbol.

In Figure 13.3(a), a V-groove weld is shown without a dimension. Therefore, the size or depth of the weld is assumed to be equal to the thickness of the pieces.

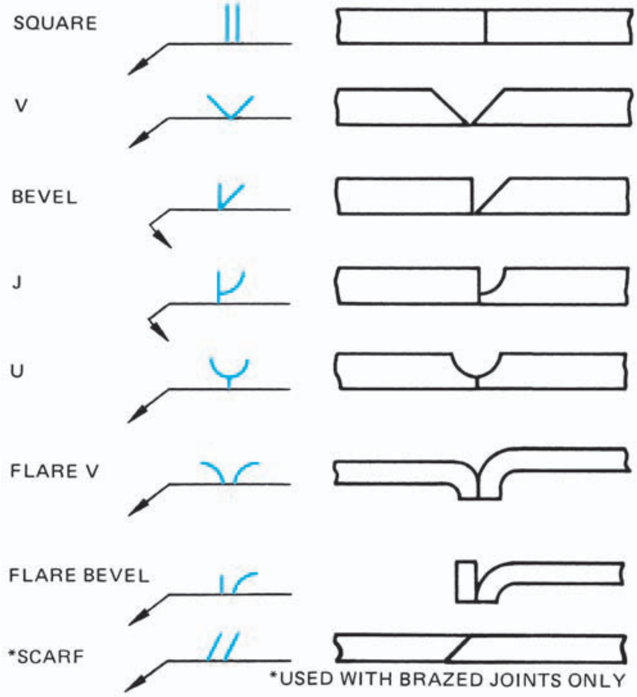
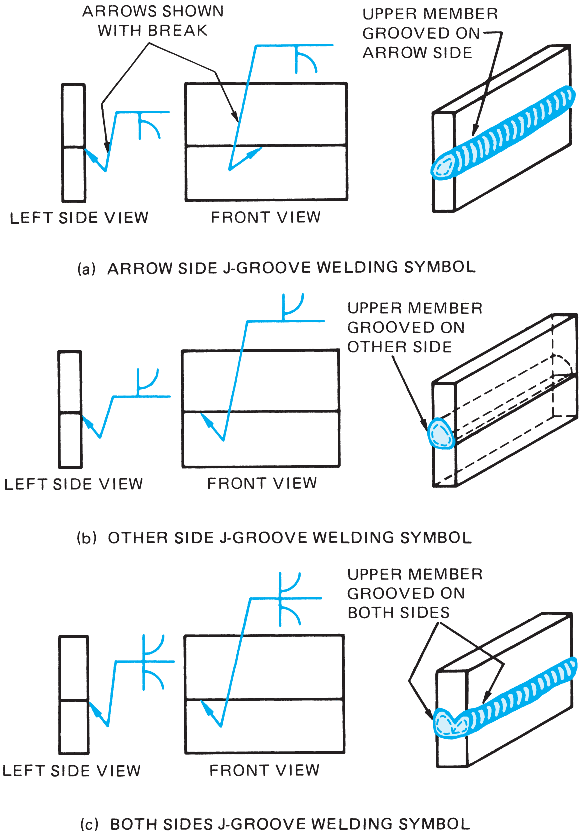


FIGURE 13.1 ■ Grove weld symbols and joints.


ARROWS SHOWN WITH BREAK
UPPER MEMBER GROOVED ON ARROW SIDE
LEFT SIDE VIEW
FRONT VIEW
UPPER MEMBER GROOVED ON OTHER SIDE
LEFT SIDE VIEW
FRONT VIEW
UPPER MEMBER GROOVED ON BOTH SIDES
LEFT SIDE VIEW
FRONT VIEW

(a) ARROW SIDE J-GROOVE WELDING SYMBOL

(b) OTHER SIDE J-GROOVE WELDING SYMBOL

(c) BOTH SIDES J-GROOVE WELDING SYMBOL

FIGURE 13.2 ■ J-groove weld.

Figure 13.3(b) shows a ½″ V-groove weld. The depth of the groove indicated by the dimension placed to the left of the symbol signifies that each member is to be prepared prior to welding with a bevel having a ½″ depth.

Figure 13.3(c) shows the proper position of the dimension for the groove size when dimensioning double groove welds. The dimensions are located to the left of the symbols as shown.

Figures 13.3(c) and (d) show the correct procedure for applying included angles to a welding symbol. Note that the dimensions are placed to the left of the weld symbol and the angle notation is placed above and below the symbol even when the angles are the same.

Figure 13.3(e) shows a dimensioned U-groove weld, which is to be made on the other side of the joint. Again, the dimension refers to the depth of the groove.

In Figure 13.3(f), the dimensioning of a double bevel weld is shown where both welds are not the same size. On the arrow side of the joint, the size is ⅞″; the other side size is ¼″. Note the direction in which the arrow breaks to indicate which member is to be grooved.

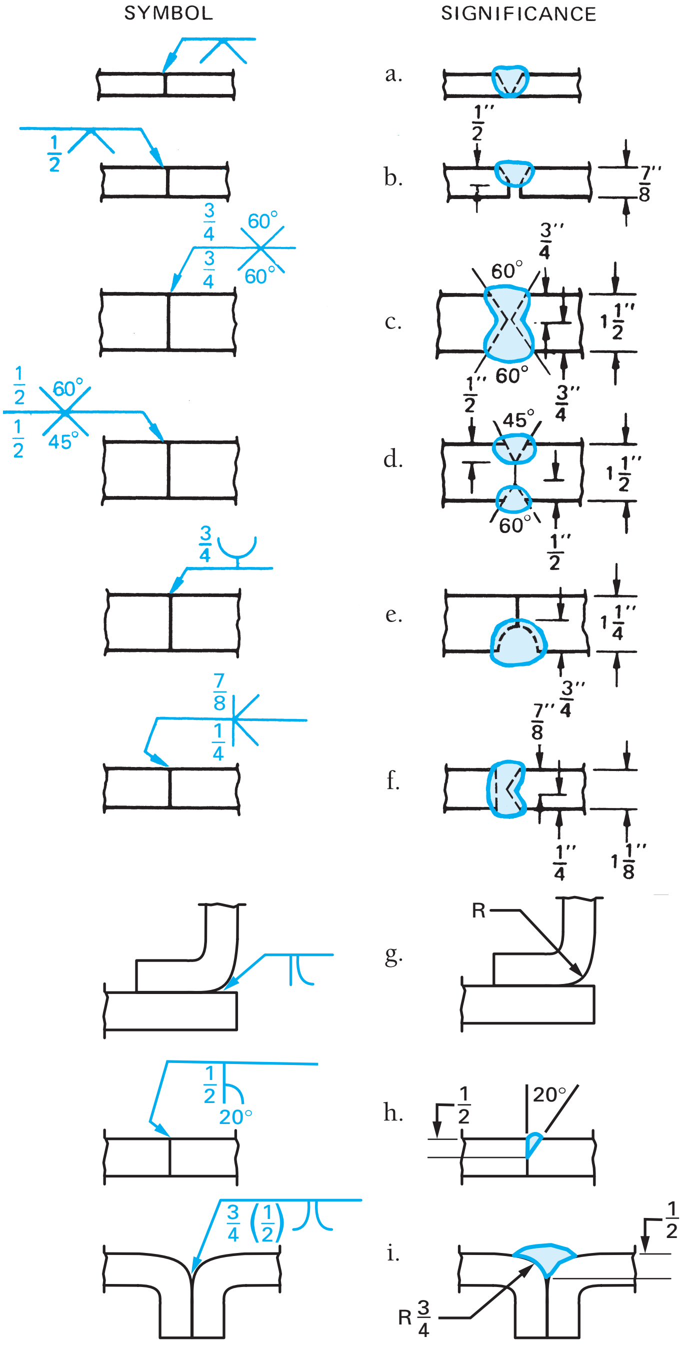


FIGURE 13.3 ■ Specifying groove weld sizes.

GROOVE WELD SIZE

The groove weld size is the depth of the material actually included and fused in the weld, Figure 13.4(a).

If the weld is to have partial penetration, the dimension of both the groove size and the groove weld size should be given. The welding symbol shows these two dimensions to the left of the weld symbol, Figure 13.4(b). They are shown as: depth of preparation (S) and groove weld size.

In some cases the groove weld size may be smaller than the groove, Figure 13.4(c) and Figure 13.4(d). In others, the groove weld size (E) may be equal to the depth of groove (S), Figure 13.4(e). To determine the actual placement of the weld bead, specific instructions must be followed.

The groove weld size (E) dimension may be shown with a weld symbol without necessarily including a depth of preparation size (S). Such an application is indicated with a square groove symbol in Figure 13.5.

Under certain conditions, the groove size or the weld symbol may not be given. When this information is not given, a note is usually included on the drawing to indicate the joint preparation as optional, with a complete joint penetration specified. In such cases, the letters “CJP” (complete joint penetration) are placed in the tail of the reference line. The welding symbol is then shown as illustrated in Figure 13.6.

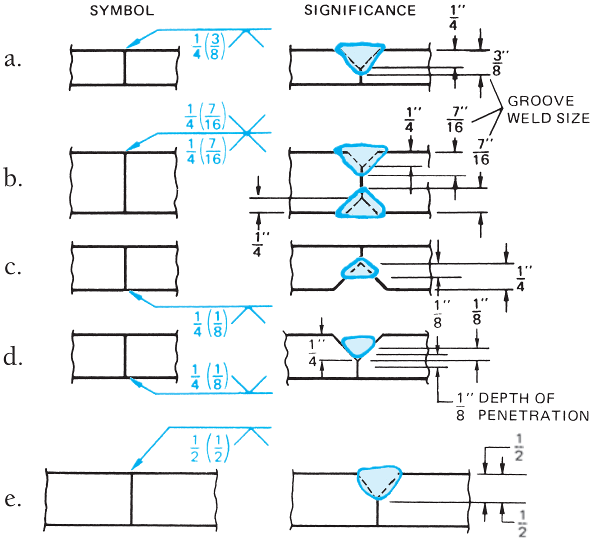


FIGURE 13.4 ■ Groove weld size and joint preparation size.

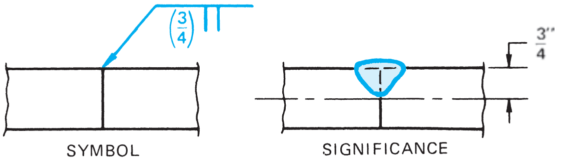


FIGURE 13.5 ■ Use of weld symbol showing groove weld size only, no joint preparation required.

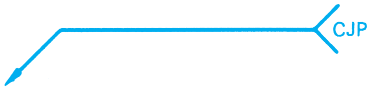


FIGURE 13.6 ■ Welding symbol showing complete joint penetration.

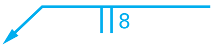
LENGTH AND PITCH OF GROOVE WELDS

The length of a groove weld is specified by placing the dimension to the right of the weld symbol, Figure 13.7.

The length and pitch (distance between centers) of intermittent welds are specified by placing the dimensions to the right of the weld symbol and are separated by a hyphen, Figure 13.8.

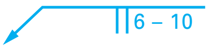
The length and pitch of intermittent welds are specified on both sides of a joint as shown in Figure 13.9. Note: Intermittent welds are also identified as **chain** intermittent welds.

When symbols are offset, the welds are identified as **staggered** intermittent welds, Figure 13.10.



8 SIGNIFIES LENGTH OF WELD

FIGURE 13.7 ■ Length of weld.



6 SIGNIFIES LENGTH OF WELD
10 SIGNIFIES PITCH OF WELD

FIGURE 13.8 ■ Length and pitch dimensions.

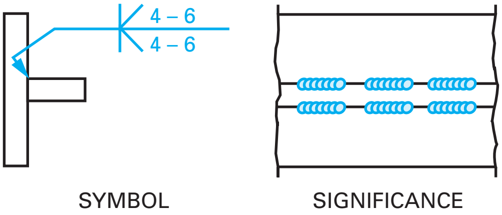


FIGURE 13.9 ■ Intermittent welds on both sides.

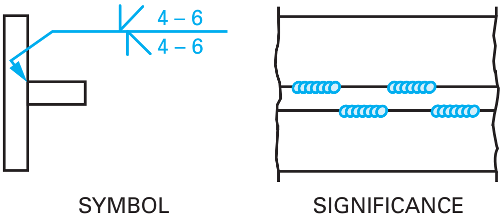


FIGURE 13.10 ■ Staggered intermittent welds on both sides.

ROOT OPENING OF GROOVE WELDS

The distance between the joint members at the bottom of the weld is called the root opening, Figure 13.11.

In many cases, manufacturers have standardized the root openings of groove welds so that they can be covered by a general note or specification. For example, “Unless otherwise indicated, root openings for all groove welds are 3⁄16″.”

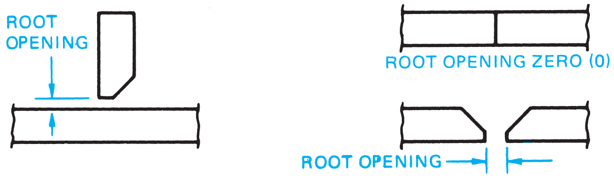


FIGURE 13.11 ■ Root opening.

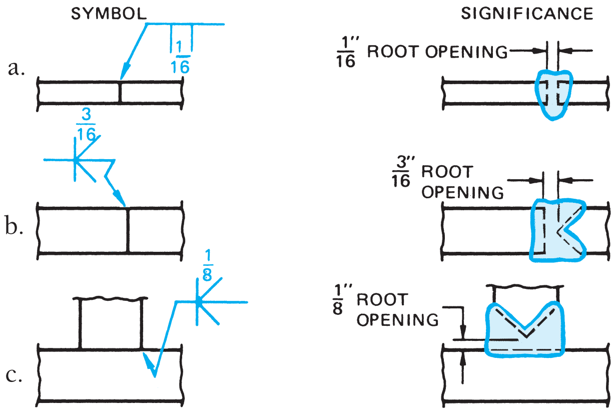


FIGURE 13.12 ■ Root opening applied to welding symbols.

When specified, the dimension for the root opening is located inside the weld symbol, Figure 13.12 and Figure 13.13. Note that for double groove welds the root opening need appear only once, Figure 13.12(b) and Figure 13.12(c). Note that when a root opening dimension is not given, the root opening is zero (0). A "0" may be used to indicate this, Figure 13.13(c).

GROOVE ANGLE

When the angle formed by the members to be welded is given, it is placed inside the weld symbol, Figure 13.14. If both the groove angle and the root opening are given, both dimensions should be placed as shown in Figure 13.15.

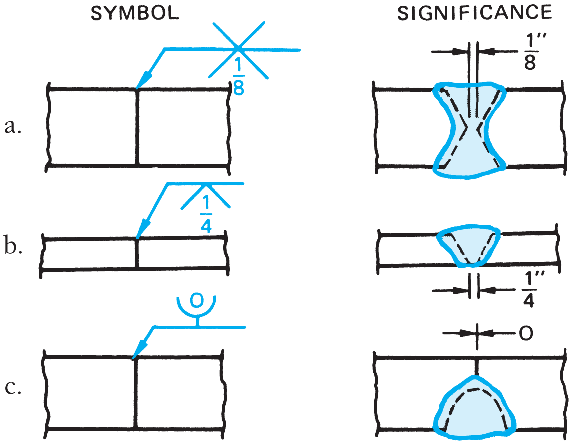


FIGURE 13.13 ■ Root opening applied to other welding symbols.

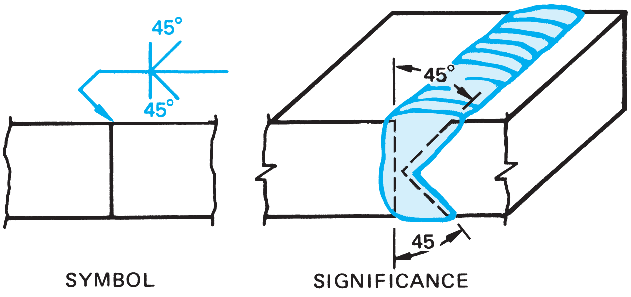
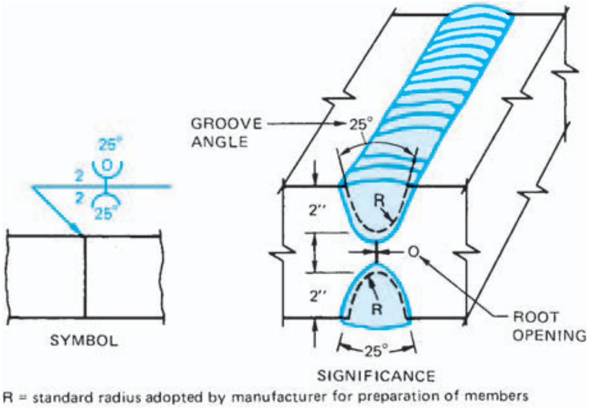


FIGURE 13.14 ■ Groove angle designation.



R = standard radius adopted by manufacturer for preparation of members

FIGURE 13.15 ■ Groove weld symbol showing use of combined dimensions.

CONTOUR AND FINISHING

The standard surface contour and finish symbols are added to the groove weld symbols as shown in Figure 13.16. Note that when a postweld finish is not specified, the contour may be approximate in shape. Also, recall that the postweld method of finish is optional when the letter "U" (for unspecified) is used with the contour symbol. It signifies an unspecified method of finish.

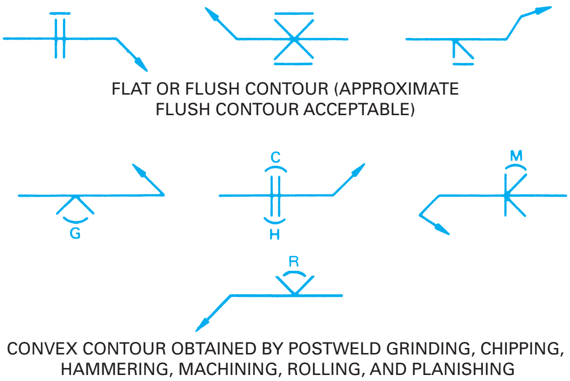

FLAT OR FLUSH CONTOUR (APPROXIMATE
FLUSH CONTOUR ACCEPTABLE)
C
M
G
H
R
CONVEX CONTOUR OBTAINED BY POSTWELD GRINDING, CHIPPING,
HAMMERING, MACHINING, ROLLING, AND PLANISHING

FIGURE 13.16 ■ Application of standard contour and finish symbols.

GROOVE WELD COMBINATIONS

Groove weld symbols may be used in combination with one another or with other weld symbols, Figure 13.17. They are used to indicate a similar or different type of groove weld, or another type of weld, on opposite sides of the joint, Figure 13.17(a), (b), and (c).

Groove welds are also used with other weld symbols to indicate a sequence of welds required on the same side of the joint, Figure 13.17(d), and on both sides, Figure 13.17(e).

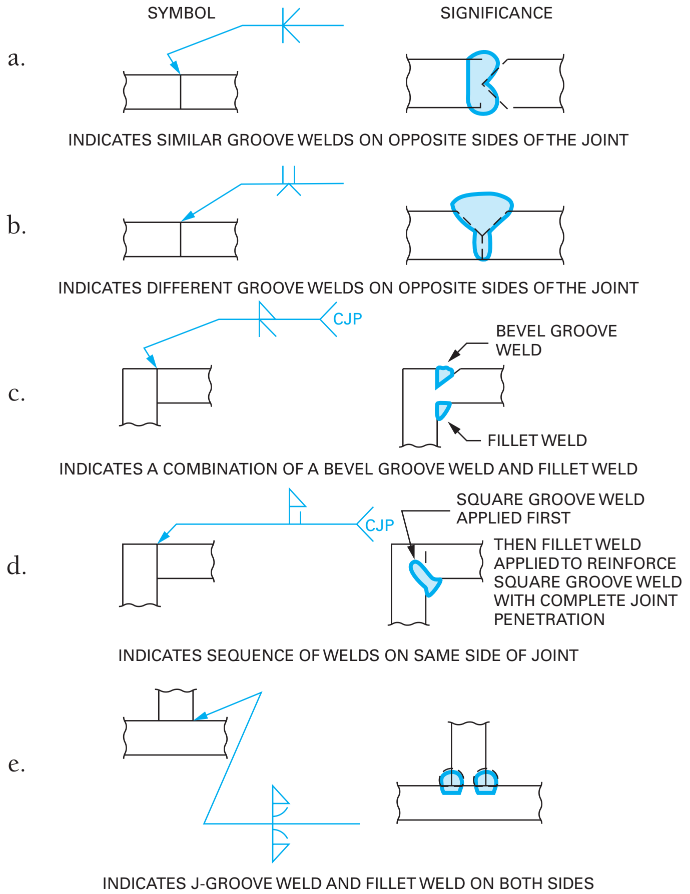

SYMBOL
SIGNIFICANCE
a.
INDICATES SIMILAR GROOVE WELDS ON OPPOSITE SIDES OF THE JOINT
b.
INDICATES DIFFERENT GROOVE WELDS ON OPPOSITE SIDES OF THE JOINT
CJP
BEVEL GROOVE WELD
c.
FILLET WELD
INDICATES A COMBINATION OF A BEVEL GROOVE WELD AND FILLET WELD
CJP
SQUARE GROOVE WELD APPLIED FIRST
d.
THEN FILLET WELD APPLIED TO REINFORCE SQUARE GROOVE WELD WITH COMPLETE JOINT PENETRATION
INDICATES SEQUENCE OF WELDS ON SAME SIDE OF JOINT
e.
INDICATES J-GROOVE WELD AND FILLET WELD ON BOTH SIDES

FIGURE 13.17 ■ Groove weld combinations.

Figure 13.18 shows a groove weld symbol used with welding symbols having multiple reference lines.

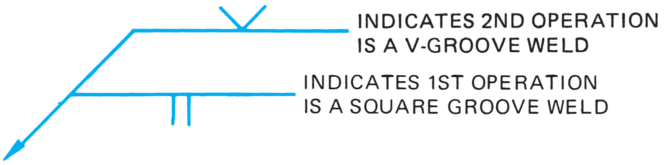

INDICATES 2ND OPERATION IS A V-GROOVE WELD
INDICATES 1ST OPERATION IS A SQUARE GROOVE WELD

FIGURE 13.18 ■ Use of groove symbols with multiple reference line welding symbol.

BACK GOUGING AND ITS APPLICATION TO GROOVE WELDS

A joint with a groove weld may include a requirement for back gouging. This operation is the removal of base and weld metal from the other side of a joint that has been groove welded. It is performed to ensure that there will be complete penetration when welded from that side. When back gouging is required, it is specified in the tail of the arrow with the words "back gouge," Figure 13.19.

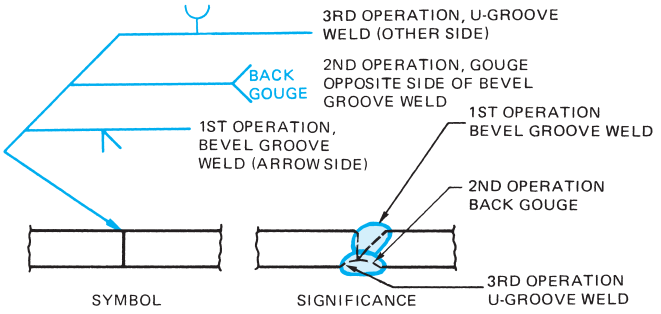

3RD OPERATION, U-GROOVE WELD (OTHER SIDE)
BACK GOUGE
2ND OPERATION, GOUGE OPPOSITE SIDE OF BEVEL GROOVE WELD
1ST OPERATION, BEVEL GROOVE WELD (ARROW SIDE)
1ST OPERATION BEVEL GROOVE WELD
2ND OPERATION BACK GOUGE
3RD OPERATION U-GROOVE WELD
SYMBOL
SIGNIFICANCE

FIGURE 13.19 ■ Application of back gouging to groove welds.

BACKING AND SPACER MATERIAL SYMBOLS AND THEIR APPLICATION TO GROOVE WELDS

Backing Material Symbol

Single groove joints may include the addition of backing material at the root of a joint for the purpose of supporting molten weld metal. The backing material may or may not be removed following completion of the weld.

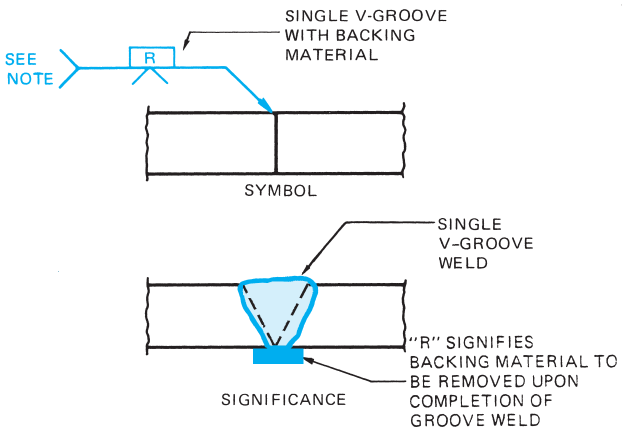

SEE NOTE
R
SINGLE V-GROOVE WITH BACKING MATERIAL
SYMBOL
SINGLE V-GROOVE WELD
"R" SIGNIFIES BACKING MATERIAL TO BE REMOVED UPON COMPLETION OF GROOVE WELD
SIGNIFICANCE

FIGURE 13.20 ■ Application of backing material symbol with a V-groove weld symbol.

The supplementary "backing material" symbol is used with single-groove weld symbols. The symbol is placed on the side opposite the groove weld symbol, Figure 13.20. If the backing material is to be removed following the completion of the groove weld, an "R" notation is used and is located within the symbol; otherwise, the backing material may be left in place.

Note that a tail is always used on the welding symbol when a backing or spacer material is used. A "See Note" reference is included in the tail to refer to a note on the drawing for the kind of backing or spacer material to be used and its dimensions, or this information is included in the tail itself.

Spacer Material Symbol

A groove weld may include a metal strip or bar inserted at the root of the groove joint. It is used to maintain the root opening of a joint, or to bridge members of a joint with an exceptionally wide gap. After the initial weld is completed, spacers may be removed by back gouging and the second weld is completed from the opposite side or the spacer may become an integral part of the weld.

The "spacer material" symbol is used with a single or double groove weld symbol. It modifies the shape of the groove weld symbol by the addition of a rectangle within the groove symbol, Figure 13.21. Note that the spacer material symbol is shown centered on the reference line.

Typical applications of the spacer material symbol are shown in Figure 13.22.

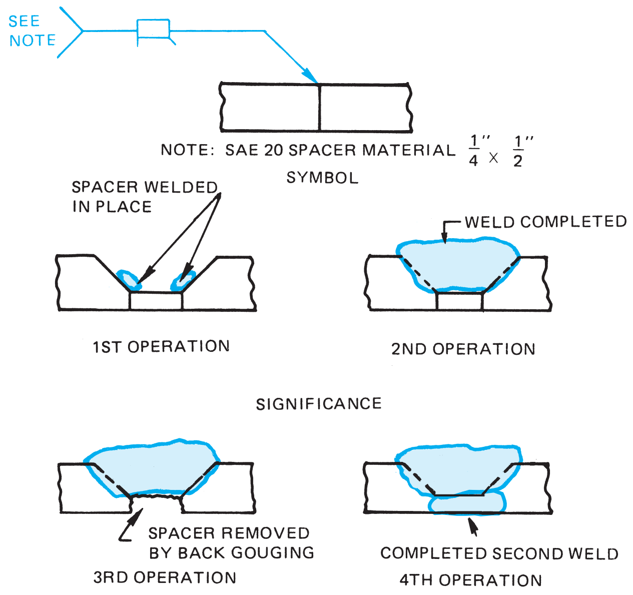


FIGURE 13.21 ■ Application of spacer material symbol with a bevel groove symbol (modified).

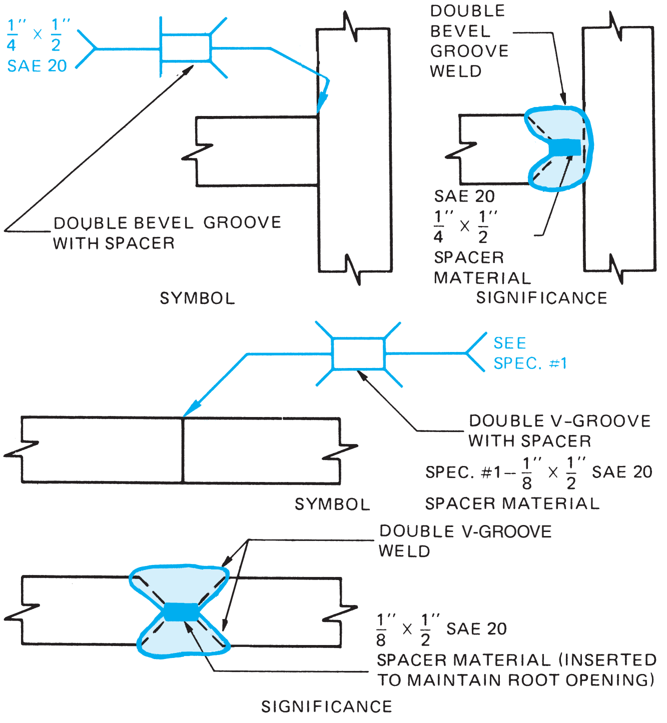


FIGURE 13.22 ■ Applications of spacer material symbol including size and kind of spacer material.

CONSUMABLE INSERTS AND THEIR APPLICATION TO GROOVE WELDS

Consumable inserts may be used in conjunction with single groove welds. The insert is a filler metal that is fused into the root of the joint and becomes a part of the weld. The symbol for indicating a consumable insert is a square shape _⊓_ and is located on the opposite side of the groove weld symbol, Figure 13.23. When an insert is specified, a tail is included as part of the welding symbol for inclusion of the class of insert, Figure 13.23. Note that consumable inserts are used in critical applications to make complete joint penetration welds from one side only. They are usually used in pipe welding. Information on consumable inserts may be found in AWS A5.30, published by the American Welding Society.

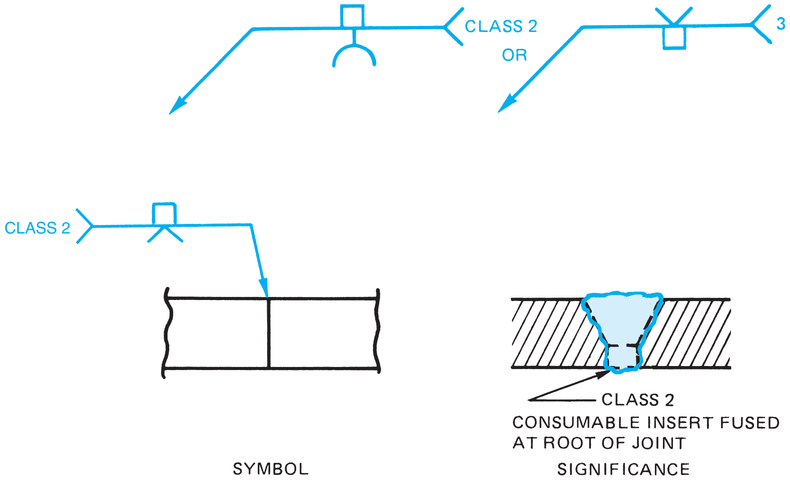
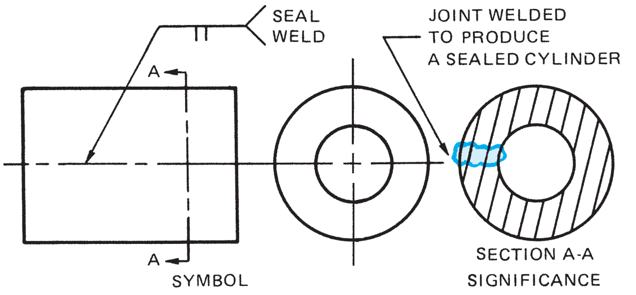


FIGURE 13.23 ■ Application of consumable insert symbol.

SEAL WELDS

Groove welds may be specified as performing a sealing function only, such as when fabricating tanks and other metal containers that must be leakproof. When such is the case, a note is included in the tail of the welding symbol to specify this requirement, Figure 13.24. Note that a consumable insert may be used in the joint of a seal weld.



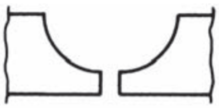
NOTE: A GROOVE WELD SYMBOL WITHOUT THE SIZE OF THE WELD DIMENSION REQUIRES COMPLETE JOINT PENETRATION (CJP). IF CJP IS NOT NECESSARY, THE SIZE OF THE WELD DIMENSION IS SPECIFIED TO THE LEFT OF THE WELD SYMBOL.

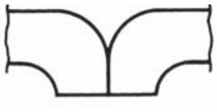
FIGURE 13.24 ■ Application of a note to the welding symbol for indicating a seal weld.

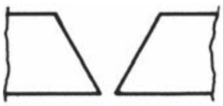
UNIT 13: REVIEW A

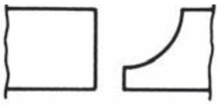
Graph paper is provided at the end of each review for your use.

1. Identify the types of groove welds represented by the following illustrations:

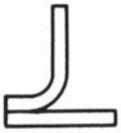
a.


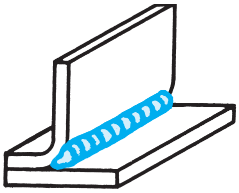
b.


c.


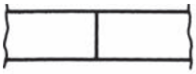
d.


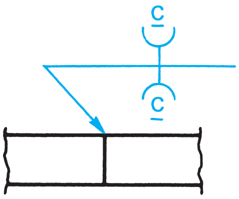
2. Apply the welding symbol to sketch A that specifies the weld shown by sketch B.


A.


B.

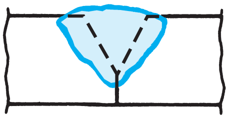
3. Complete sketch A to show the significance of the weld symbol in sketch B.

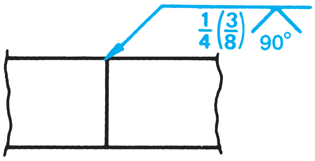

A.



B.

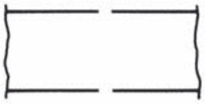
4. Add the necessary extension and dimension lines (including the dimensions) to sketch A to show the significance of ¼(⅜) and 90° dimensions shown in sketch B.

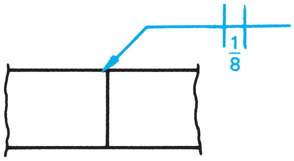

A.



B.

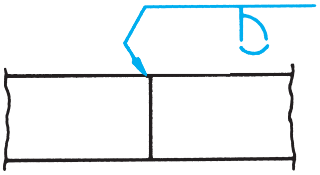
5. Complete sketch A to show the significance of the weld symbol shown in sketch B.


A.



B.

6. a. Mark the member to be grooved with an X for the following joint.



b. What type of weld is to be made? ___________

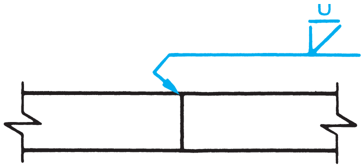
c. What is the length of the weld? ___________

d. What is the contour specified? ___________

e. Is a postweld finish required? ___________

f. Explain your answer to (e). ___________

7. a. Explain the significance of the following welding symbol.

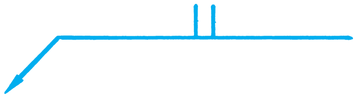


b. Mark the member to be grooved with an X.

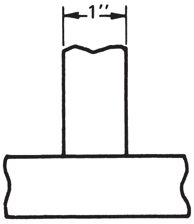
c. Is a postweld finish required? Explain.

8. Show by a sketch the significance of the following specification: “Unless otherwise indicated, root openings for all V-groove welds to be ⅛″.”

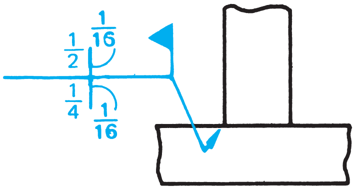
9. Complete the following weld symbol to include a class 3 consumable insert. Also include what is required to indicate a seal weld. The size of the weld is to be ⅛″.



10. Complete sketch A to show the significance of the welding symbol shown in sketch B.

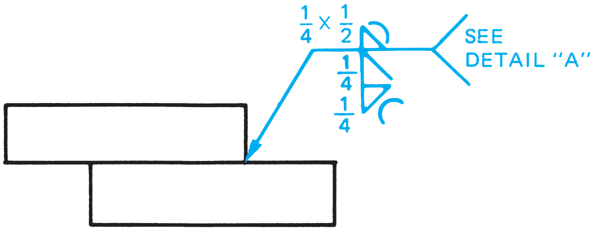


A.



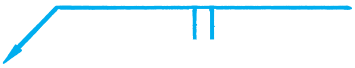
B.

11. a. Explain the significance of the following weld symbol including the note in the tail.



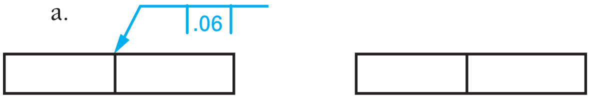
b. Show by a sketch how the welds will appear.

12. Complete the following weld symbol to signify complete joint penetration with a planished flat finish.

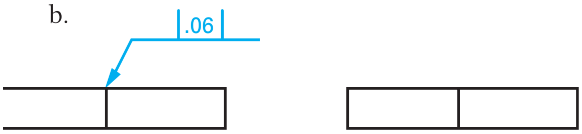


13. Refer to illustrations (a) through (i) as follows and complete how the weld would appear in the adjacent illustrations. Include dimensions.

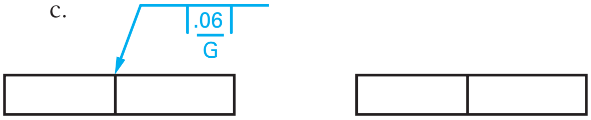
a.



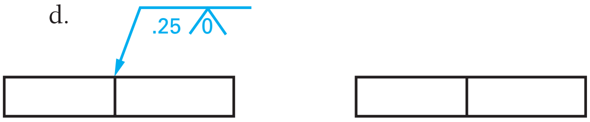
b.



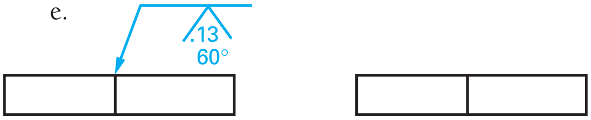
c.



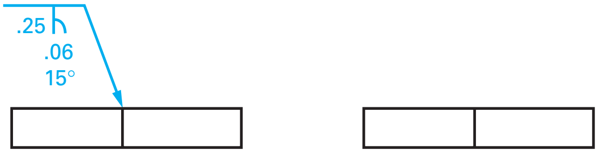
d.



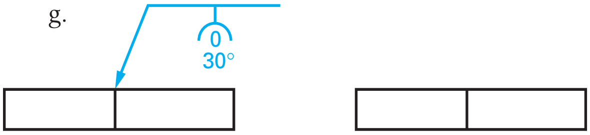
e.



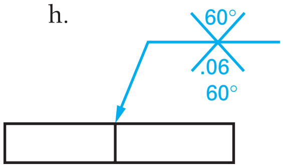
f.



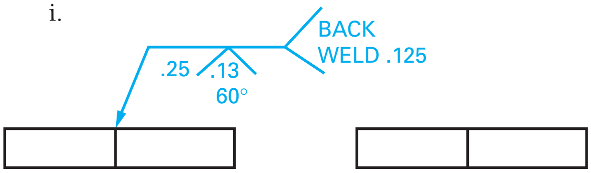
g.



h.

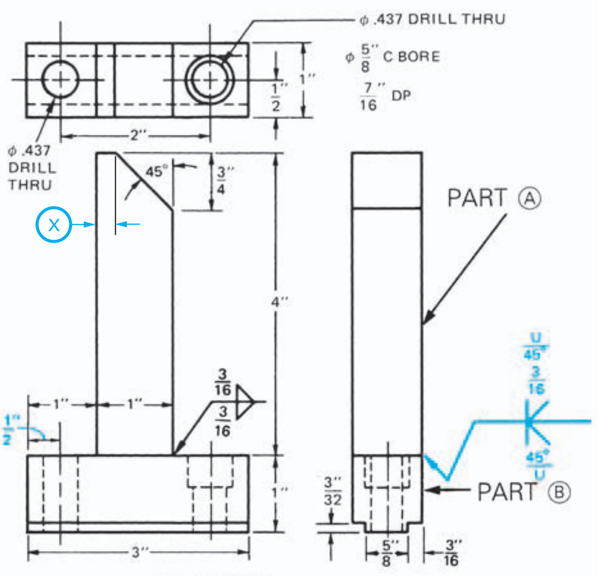


i.



UNIT 13: REVIEW B

Refer to the drawing, Slide Support, below.



SLIDE SUPPORT

1. Sketch the groove welds specified and show all given weld dimensions.

2. What is the total length of fillet welds called for?

   ____

3. What is the total length of groove welds called for?

   ____

4. What is the root opening of the groove welds?

   ____

5. What is the contour and postweld finish required for the groove welds?

   ____

   ____

6. a. Which member requires joint preparation?

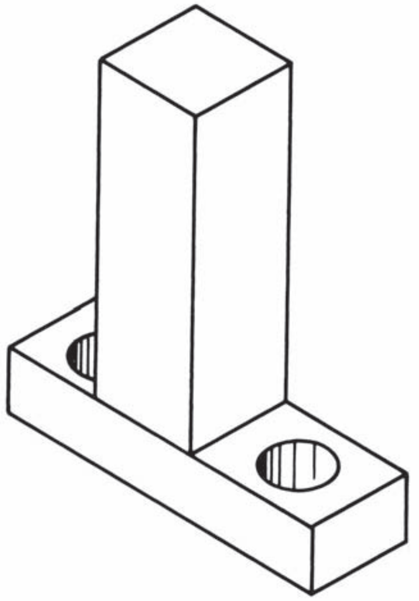
   ____

   b. Sketch how the joint member would appear.

7. What size is dimension Ⓧ?

   ____

8. The pictorial sketch of the slide support assembly which follows is incorrect.
   a. Make the necessary changes to correct it.
   b. Dimension the sketch.
   c. Sketch the welds called for and identify each.
   d. Sketch the joint preparation required by the welding.



9. List the location dimensions for the c' bore hole.

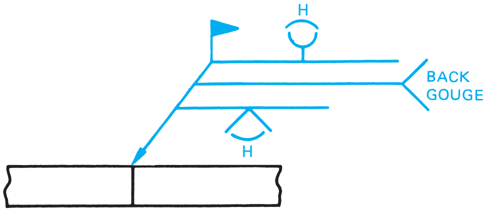
   ____

10. What is the fractional size of the ∅ . 437 drilled hole?

    ____

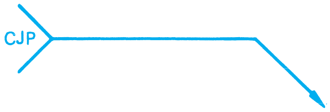
UNIT 13: REVIEW C

1. a. Explain the significance of the following welding symbol.

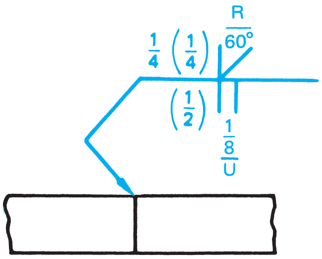


b. Sketch how the welds will appear.

2. Explain the significance of the following welding symbol.

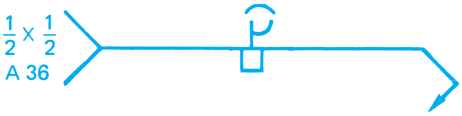


3. a. Explain the significance of the following welding symbol.

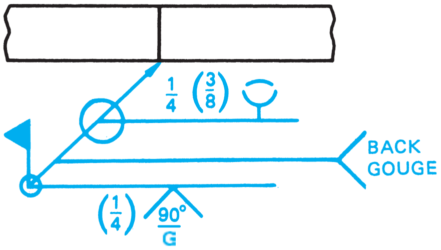


b. Sketch how the welds will appear.

4. Explain the significance of each element contained in the following welding symbol.



5. a. Identify the elements shown on the following welding symbol.

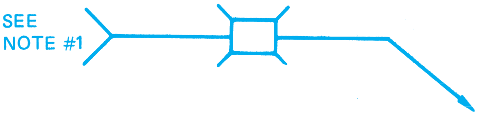


b. Sketch how the welds will appear.

6. a. Explain what is meant by "back gouging."

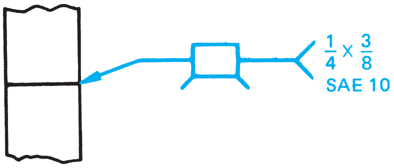
b. Describe where back gouging is indicated on the welding symbol.

7. a. Identify the elements shown on the following welding symbol.

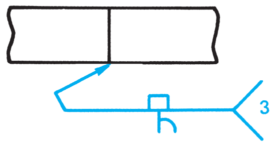


b. Sketch the welds required by the symbol given in question 7a.

8. a. Identify the elements applied to the following welding symbols.

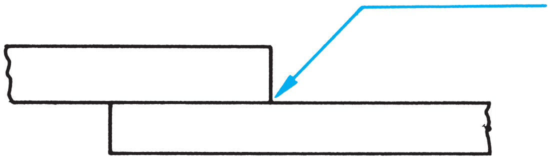


b.



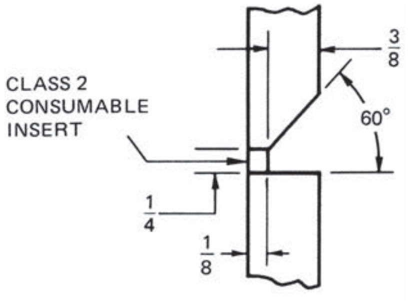
c. Sketch the weld required by the symbol given in question 8a.

9. Apply the proper elements to the welding symbol given to specify J-groove welds on both sides, followed by fillet welds on both sides, with postweld machine finished with flat contours.

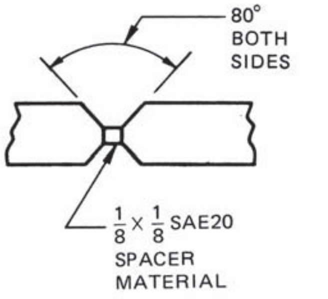


10. Sketch the welding symbol that indicates the joint preparation and other elements required for each of the following illustrations.

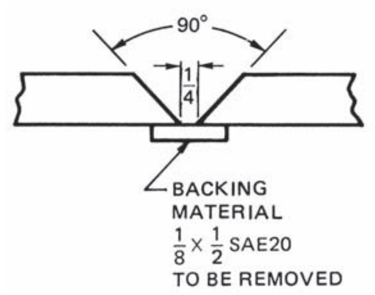
a.



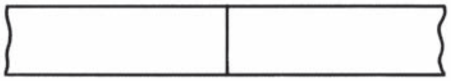
b.



c.



11. Apply the welding symbol to the following joint members to indicate an other side square groove weld with ⅛″ root opening having a class 3 consumable insert located on the arrow side.



UNIT 13: REVIEW D

Refer to Foldout Drawing 5: Mold Positioner.

1. Identify the views shown on the mold positioner two-page drawing.

   Page 1 ______________________

   ____

   Page 2 ______________________

   ____

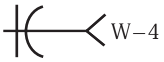
2. List the distance dimension for:

   Ⓐ—Ⓑ—Ⓒ—Ⓓ—Ⓔ______

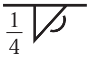
   Ⓕ—Ⓖ—Ⓗ—Ⓘ—Ⓙ______

   Ⓥ—Ⓧ—Ⓩ______

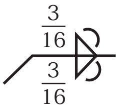
3. Interpret the following welding symbols found on the drawing:

a. 

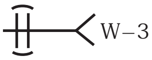
____

b. 

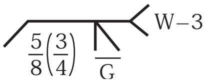
____

c. 

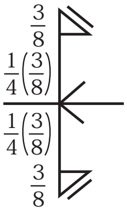
____

d. 

____

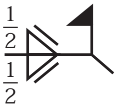
e. 

____

f. 

____

____

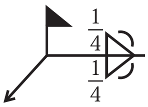
g. 

____

____

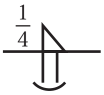
____

____

h. 

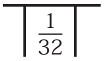
____

____

i. 

____

____

j. 

____

____

4. a. What size and kind of pipe is specified at each end of the "Positioner"?

   ____

   ____

   b. What is the length of each piece?

   ____

5. List the dimensions applicable to the following letters, Ⓐ thru Ⓩ.

   Ⓐ ____________ Ⓘ ____________

   Ⓑ ____________ Ⓙ ____________

   Ⓒ ____________ Ⓚ ____________

   Ⓓ ____________ Ⓛ ____________

   Ⓔ ____________ Ⓝ ____________

   Ⓕ ____________ Ⓦ ____________

   Ⓖ ____________ Ⓨ ____________

   Ⓗ ____________ Ⓩ ____________

6. List the size dimensions for cutting the rectangular flame cut hole.

   ____

   ____

7. a. How many dimensioned square groove welds are required? ______________

   b. What is the dimension(s) specified?

   ____

c. With a sketch, illustrate the significance of the dimensions.

8. Identify where surface finishes are specified.

9. What is the overlong length of the mold positioner?

10. a. List the sizes of the s-beams specified.

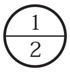
b. Identify the geometric configuration required at each end of the s-beam(s).

11. a. What size pipe is required to be welded to part Ⓜ and the I-beam?

b. What is the length for each piece of pipe?

c. What is the wall thickness of the pipe? (Refer to Appendix 3.)

12. What is the significance of the following symbol(s)?



Mold positioner ______________

13. List the specifications for welds to be made.

W-1 ______________

W-2 ______________

W-3 ______________

W-4 ______________

14. a. Sketch the weld specified for the 3″ standard pipe.

b. What is the significance of the W-3 shown in the tail of the symbol?

c. What is the length of the pipe required?

15. What is the millimeter equivalent for dimension 2″? Refer to the conversion table on print #1.

16. Identify the detail drawing for the U channel.

17 a. What size material is required for making the "Base" supporters?

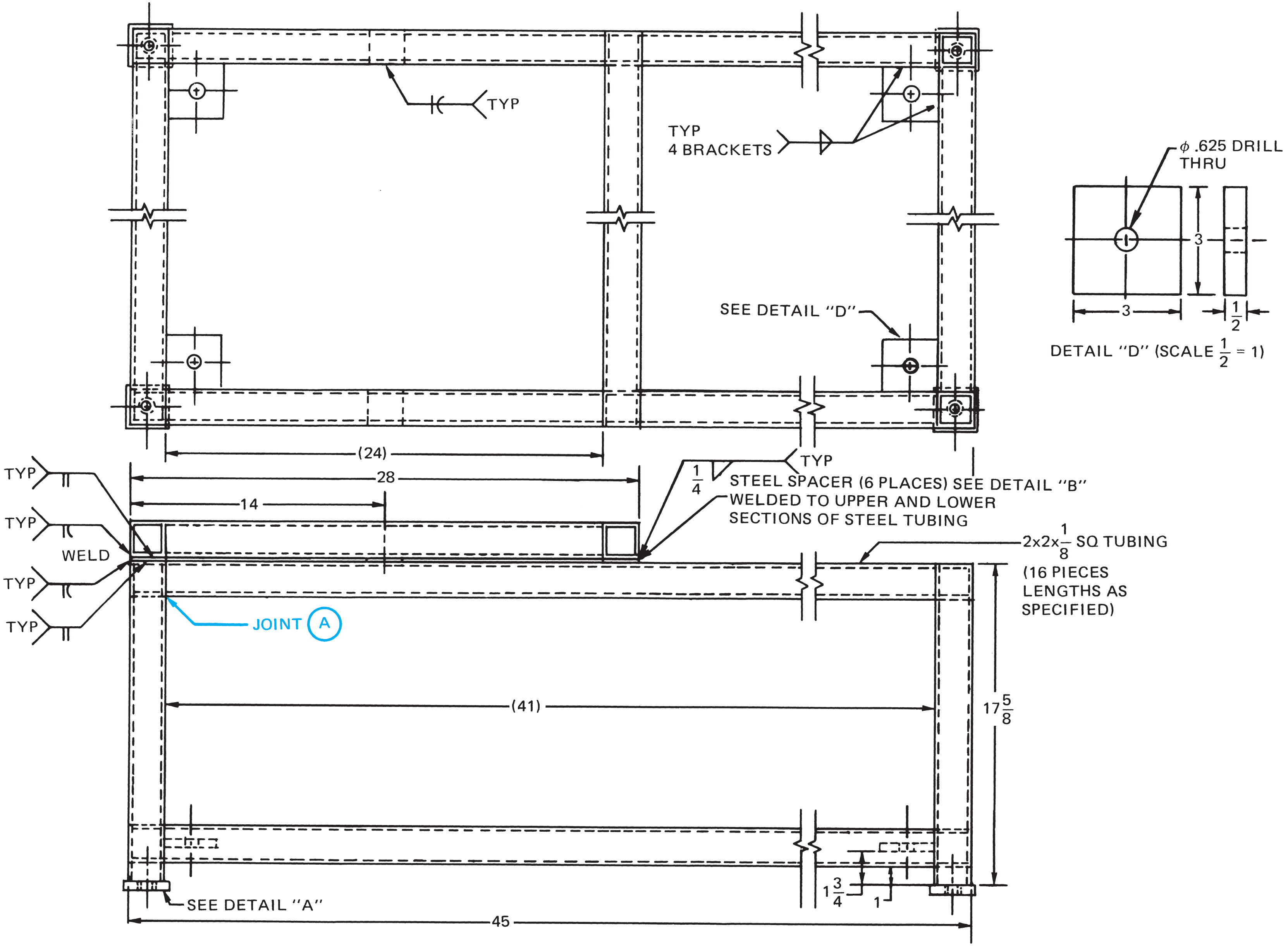
b. How many supports are required?

c. What method is to be used for fitting the pin assembly?

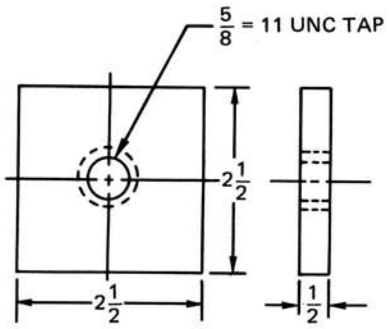
18. What material size is required for the "End Plate Assembly"?

19. What material size is required for Part Ⓟ ?

20. At what point in the assembly are spacers to be installed?

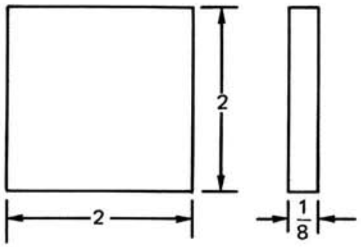

TYP
TYP
4 BRACKETS
SEE DETAIL "D"
φ .625 DRILL
THRU
3
3
1/2
DETAIL "D" (SCALE 1/2 = 1)
(24)
28
14
TYP
TYP
TYP
WELD
TYP
TYP
1/4
STEEL SPACER (6 PLACES) SEE DETAIL "B"
WELDED TO UPPER AND LOWER
SECTIONS OF STEEL TUBING
2x2x1/8 SQ TUBING
(16 PIECES
LENGTHS AS
SPECIFIED)
JOINT
A
(41)
17 5/8
1 3/4
1
SEE DETAIL "A"
45

MATERIAL:
STEEL PLATE



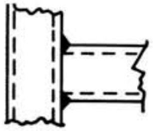
DETAIL "A", LEG BASE — 4 PIECES REQ'D

SCALE $\frac{1}{2}$ = 1



DETAIL "B" STEEL SPACER — 6 PIECES REQ'D

SCALE $\frac{1}{2}$ = 1

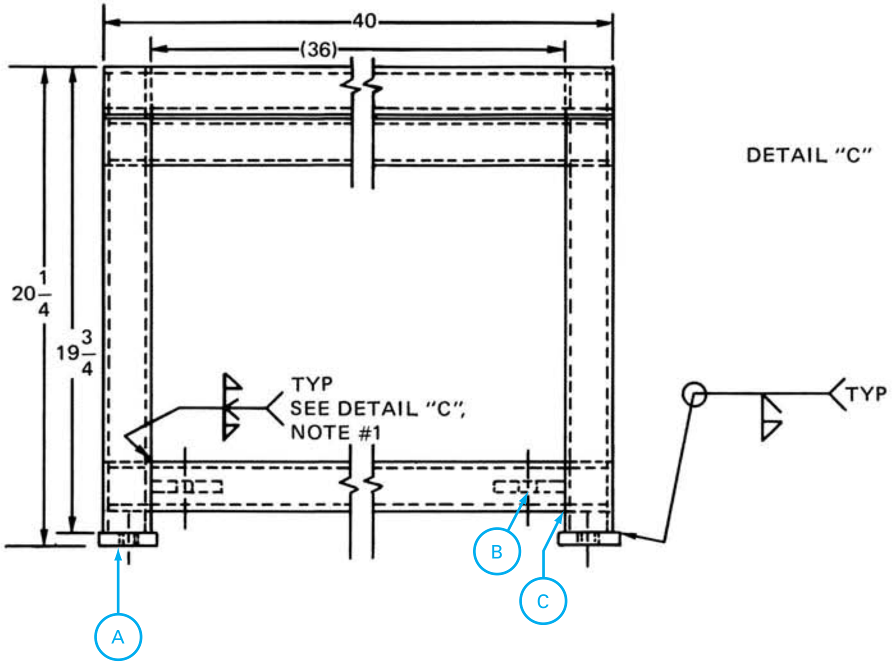


NOTE #1: 2"□ STEEL TUBING, BUTT JOINTS
WELDED ACCORDING TO DETAIL "C"

DETAIL "C"

SCALE $\frac{1}{4}$ = 1

DETAIL "C"



TOLERANCES (EXCEPT AS NOTED)	
DECIMAL	± .005
FRACTIONAL	± $\frac{1}{16}$
ANGULAR	± 2°

REVISIONS		
NO.	DATE	BY
1		
2		
3		
4		
5		

AUTOMATED DYNAMICS CORP.		
ROBOT TABLE		
DRAWN BY L. J. SIY	SCALE $\frac{1}{4}$ = 1	MATERIAL STEEL
CHK'D	DATE	DRAWING NO.
DESIGNED BY L. RUFF	APP'D	DEO1-11-006-C

UNIT 13: REVIEW E

Refer to the drawing, Robot Table, pages 186 and 187.

1. Identify the name of the unit to be fabricated.

   ____

2. List the tolerances that are to be applied.

   Decimal: ______________________________

   Fractional: ______________________________

   Angular: ______________________________

3. a. How many spacers are required? __________

   b. What kind of material is to be used for the spacers?

   ____

4. a. How many tapped holes are required?

   ____

   b. What size tap is to be used? __________

   c. What tap drill size is required?

   ____

   d. Explain the significance of each item in the thread specification.

   ____

   ____

5. What scale size is used for the detail drawings?

   ____

6. List two reference dimensions found on the print.

   ____

7. a. How many ∅. 625 drilled holes are required?

   ____

   b. What is the fractional size of these drills?

   ____

8. Identify the weld(s) required for fastening each leg base to the square tubing.

   ____

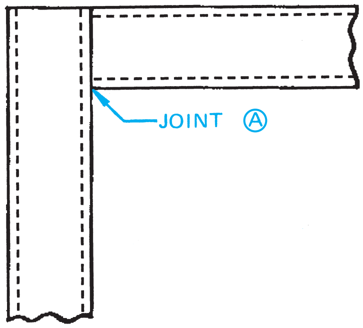
   ____

9. Identify the weld(s) required for fastening the spacers to the square tubing.

   ____

   ____

10. Modify the following sketch to show how joint Ⓐ is to be prepared for welding. Fill in the weld as it would appear at the joint.



11. a. What size angle is required for the square tubing joints?

    ____

    b. What is the maximum angle size permitted?

    ____

    c. What is the minimum angle size permitted?

    ____

12. How many pieces of 2″☐ tubing, 17⅝″ long, are required?

    ____

13. What is the total length of 2″☐ tubing that is required to fabricate the table? Allow ¼″ for cutting and finishing each piece.

    ____

14. Explain the use of “TYP” as found in the tail of the welding symbols.

    ____

    ____

15. Explain the purpose of a reference dimension.

    ____

    ____

16. How many joints require that they be welded all around?

    ____

17. What do the break lines indicate?

18. How many fillet welds are required?

19. How many square groove welds are required?

20. How many flare bevel welds are required?

21. Since the size of fillet welds is not specified, what standard should be used for determining their size?

22. Identify the views shown on the drawing.

23. Identify the kind of drawing that is used for the production of the Robot Table.

24. a. Sketch the welding symbol showing a multiple weld on one side. Use multiple reference lines.
    b. List the sequence of welds.

25. a. Sketch the welding symbol found on the drawing showing multiple welds on both sides.
    b. Describe the joint preparation required for both sides.

26. What additional view(s) are needed to better read this drawing?

UNIT 14

Back or Backing and Melt-Thru Welds

Back or backing and melt-thru welds are frequently used with groove welds to strengthen the weld on the opposite side of the joint.

A back weld is distinguished from a backing weld only by its sequence of application with respect to the face side of the groove weld. In the case of a back weld, the groove weld is made first and then the back weld is applied. In contrast to this, the backing weld is applied first and then the groove weld is made. Actually, the back and backing welds are the same and are shown by the symbol: ⌓. Either is specified by including a reference in the tail of the welding symbol, Figure 14.1. A distinction may also be made by use of multiple reference lines, Figure 14.5(d).

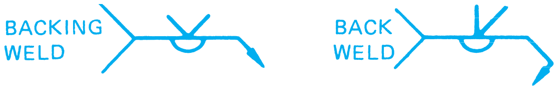


FIGURE 14.1 ■ Use of back or backing weld symbol with groove weld symbol.

The melt-thru symbol is included with the study of the back or backing symbol because of its similarity in shape and the way in which it is applied. It differs from the backing symbol in that it is shown as a solid: ⯊.

When used with groove welds, the backing, back, and melt-thru symbols are placed on the side of the reference line opposite the groove weld symbol, Figure 14.2.

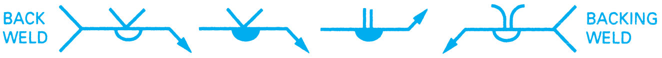


FIGURE 14.2 ■ Location of melt-thru, back, and backing weld symbols with groove weld symbols.

SIZE OF BACKING AND MELT-THRU WELDS

Dimensions that refer to backing and back welds are not applied to these symbols; however, a height of reinforcement dimension may be applied to the melt-thru symbol. It is placed to the left of the symbol, Figure 14.3. Generally, when it is necessary to specify dimensions for these welds, they are shown on a detail drawing or are included in the tail of the welding symbol.

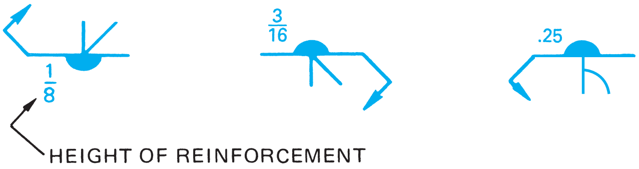


FIGURE 14.3 ■ Application of height of reinforcement dimension.

CONTOUR AND FINISHING

The contour symbols and finish abbreviations are added to the groove, backing, back, and melt-thru symbols as shown in Figure 14.4.

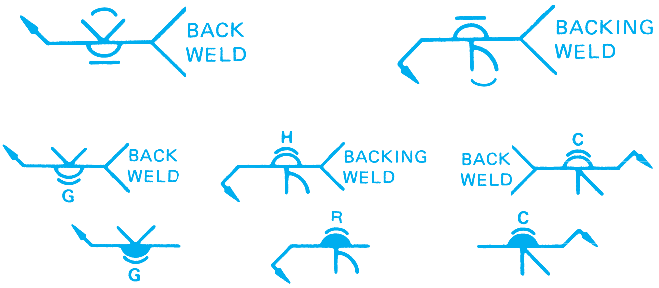


FIGURE 14.4 ■ Application of contour and finish symbols to backing, back, and melt-thru symbols.

When a backing weld or a melt-thru weld is to have a mechanically finished convex contour, this is indicated by adding the convex contour symbol and the finish abbreviation to the backing, back, or melt-thru symbol, Figure 14.4.

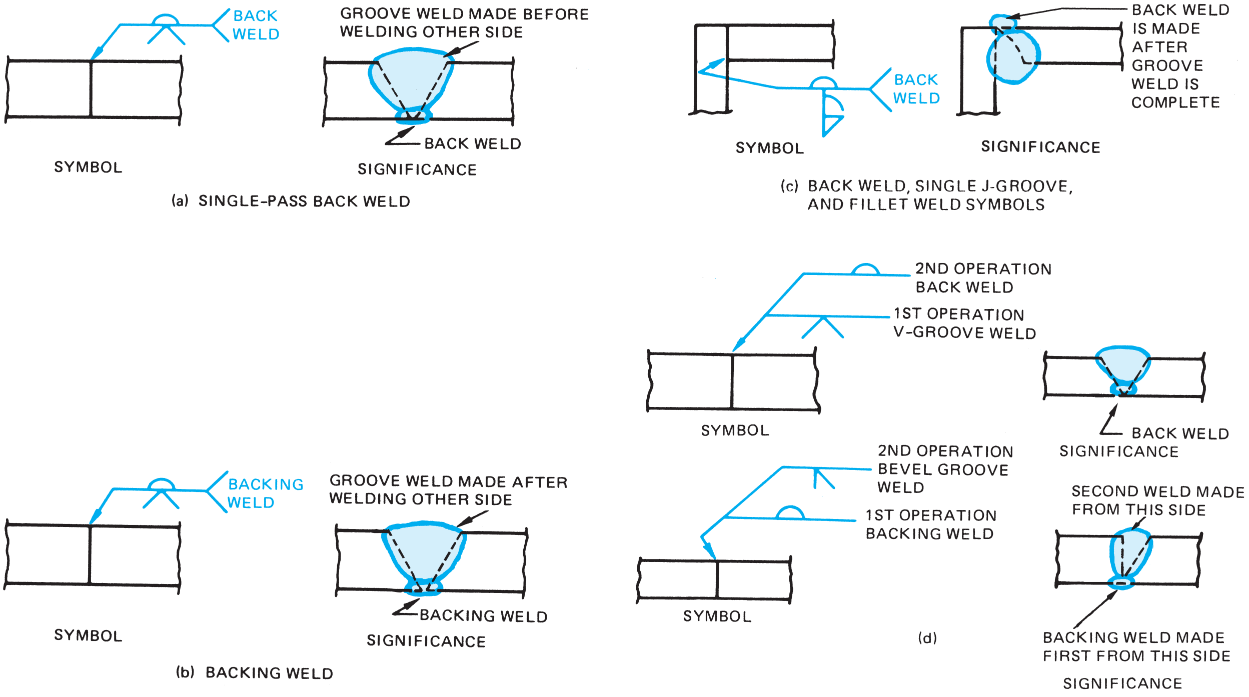
To this point, melt-thru symbols have been used in conjunction with groove symbols. However, this symbol is also used with the edge weld symbol, Unit 17.

SELECTED APPLICATIONS OF BACK OR BACKING SYMBOLS

Figure 14.4 shows several applications of the back and backing symbols. Note that Figure 14.4(a) and Figure 14.4(b) show the distinction between a back and a backing weld. Note also that a back or backing weld is easily distinguished when a multiple reference line is used, Figure 14.4(d). Observe that in all cases a reference is included in the tail to specify either a back or backing weld except when multiple reference lines are used.

SELECTED APPLICATIONS OF MELT-THRU SYMBOLS WITH GROOVE SYMBOLS

Several applications of the melt-thru symbol are shown in Figure 14.5 and Figure 14.6. In Figures 14.5(a) through (c), the melt-thru symbol is used with a groove weld. However, it can also be used for flange welds as in Figure 14.7(a) and (b). The melt-thru symbol is used in the same manner and has the same significance for flange welds as it does for groove welds.



(a) SINGLE-PASS BACK WELD

(c) BACK WELD, SINGLE J-GROOVE, AND FILLET WELD SYMBOLS

(b) BACKING WELD

(d)

FIGURE 14.5 ■ Applications of the back or backing weld symbol.

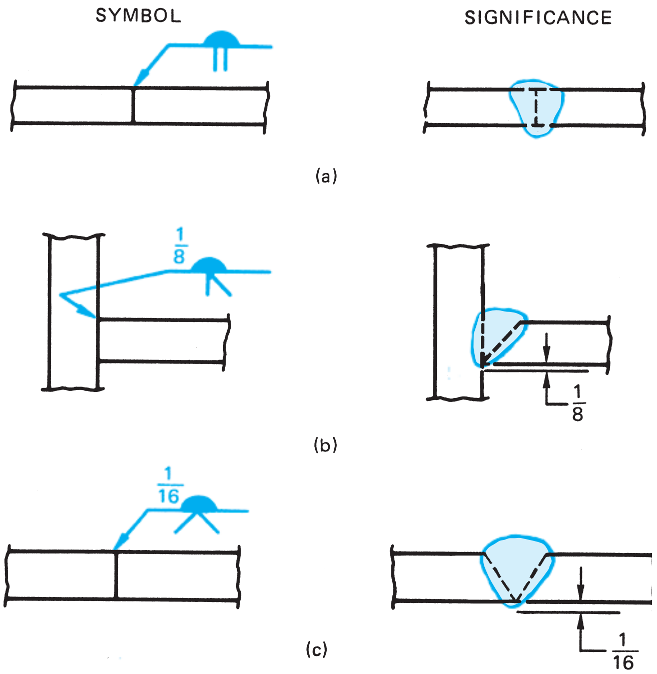
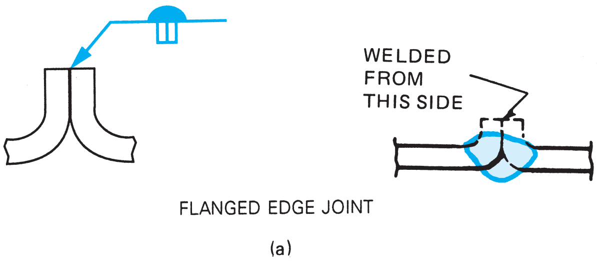


FIGURE 14.6 ■ Applications of the melt-thru weld symbol with groove welds.



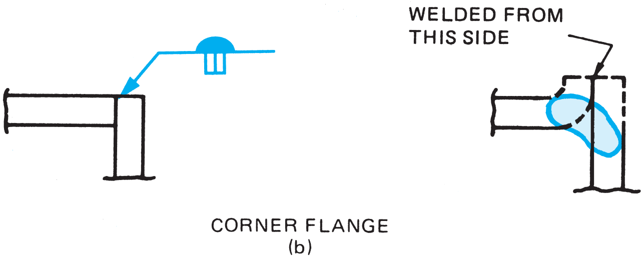


FIGURE 14.7 ■ Applications of melt-thru symbol with edge welds.

UNIT 14: REVIEW

Graph paper is provided at the end of this review for your use.

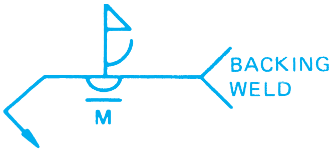
1. a. What types of welds are used with back or backing welds?

   b. Identify the types of welds to which melt-thru symbols may be applied.

2. How may the back weld be distinguished from a backing weld?

3. Sketch the welding symbols to indicate the following welds. Include a square groove weld symbol with the back and backing weld symbols.
   a. Back weld
   b. Backing weld
   c. Melt-thru weld
   d. Arrow side square groove weld with a removable backing

4. Explain each part of the following welding symbol.



Arrow side:

Other side:

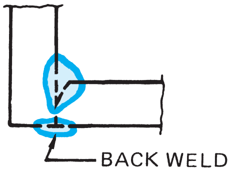
5. a. Are size dimensions generally shown for back or backing welds?

   b. What dimension may be given with a melt-thru weld symbol?

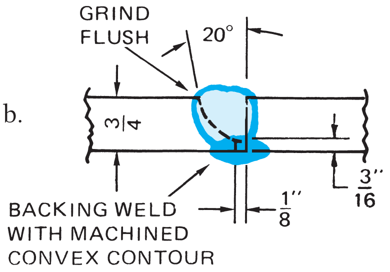
6. Sketch the symbol for the following: a single V-groove weld on the arrow side, to be grooved to a depth of ⅝″ with ⅛″ root opening and 65° included angle, weld to be chipped flat faced on arrow side. On the other side there is to be a back pass that is to be machined to a convex contour.

7. Draw the welding symbol required for the following welds:

a.



b.

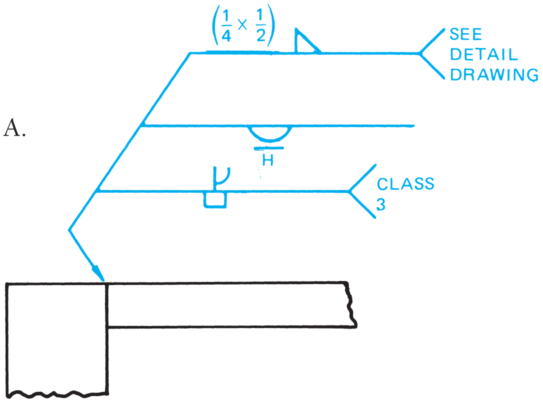


8. Sketch the welds required as indicated by the following welding symbols for A. and B. below. Indicate the sequence of welds on the sketch and identify each weld symbol.

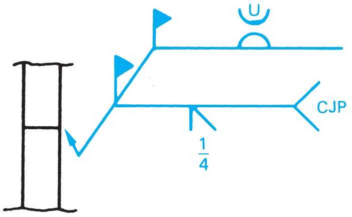
   a. Should the reference CJP be included in sketch B?

   b. Explain your answer.

A.



B.



UNIT 15

Plug and Slot Welds

The difference between the two welds, plug and slot, is in the shape of the hole in which the weld metal is deposited to fuse the two members of the joint. The plug weld is made through a round hole, and the slot weld is made through an elongated hole, Figure 15.1. Note that a plug weld symbol (not a slot weld symbol) is used to designate a fillet weld in a round or slotted hole.

Plug welds and slot welds are identified by the same symbol, ▭ except that the plug weld symbol has a diameter symbol placed on its left side ∅ ▭, Figure 15.2(a). They may also be distinguished from one another in that a slot weld is identified by reference to a detail drawing in the tail of the welding symbol. The detail drawing shows the shape, location, and orientation of the slot weld, Figure 15.2(b).

When the weld symbol for plug or slot welds is located below the reference line, the hole is in the **arrow side** member of the joint. When the symbol is located above the reference line, the hole is in the **other side** member, Figure 15.2(a) and (b). The symbol for plug or slot welds is not used to have a both sides significance.

Reference in the tail of the welding symbol may be made to specify other sources of information for preparation and completion of a slot or plug weld, Figure 15.3.

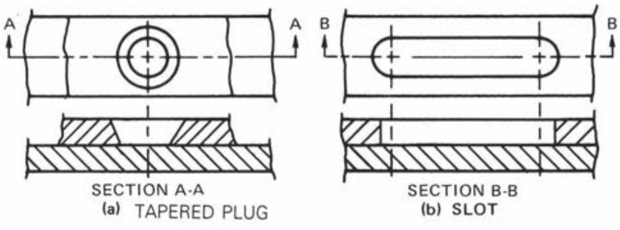
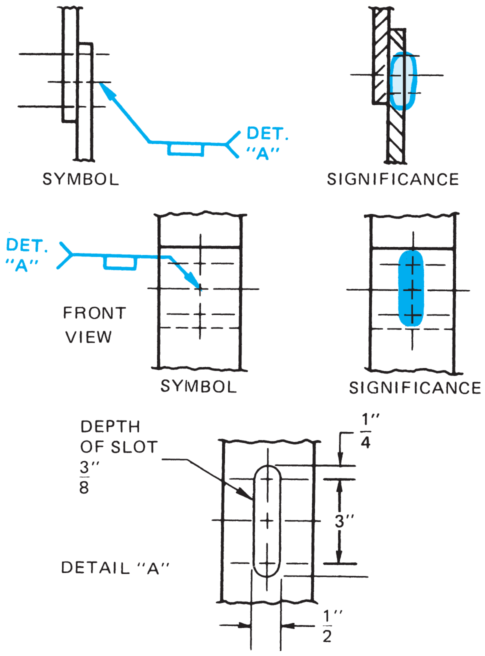


FIGURE 15.1 ■ Types of holes required to make plug and slot welds.



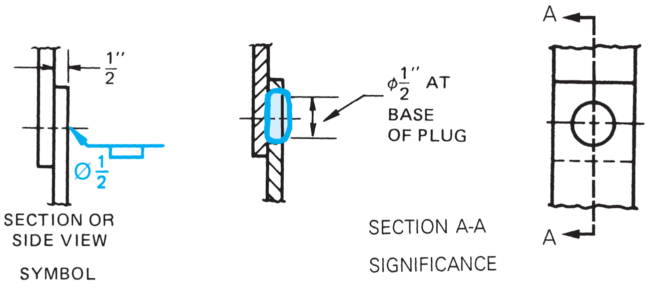


FIGURE 15.2(a) ■ Arrow side plug weld.

FIGURE 15.2(b) ■ Arrow side slot weld.

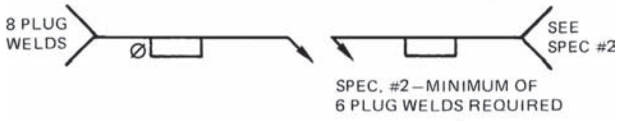


FIGURE 15.3 ■ Reference to the tail as a source for more information on plug or slot welds.

DIMENSIONS APPLIED TO THE PLUG AND SLOT WELD SYMBOL

Dimensions that may be applied to the **plug** weld symbol include size, depth of filling, included angle of countersink, number of welds and their spacing (pitch).

The **size** of a **plug weld** refers to its diameter in inches at the base of the weld. This dimension is located to the left of the weld symbol, and is preceded by the diameter symbol ∅, Figure 15.3 and Figure 15.4.

The width dimension of a **slot** weld is located to the left of the symbol. It represents the width of the minor axis of the slot at its base, Figure 15.5.

The sides of a plug or slot weld may be straight or tapered. When the sides of the hole are tapered, the included angle with a degree sign is applied on the same side of the symbol (above or below it, depending on location of the symbol) as shown in Figure 15.6.

The **number** of welds is shown in parenthesis below an arrow side of the plug and slot weld symbols or may be specified in the tail of the welding symbol. If the included angle is also to be shown, it is placed below the angle dimension. Conversely, it is shown above the symbol when the symbol has an other side significance, Figure 15.7.

The **spacing (pitch)** of plug welds may also be specified. This dimension is shown to the right of the plug weld symbol, Figure 15.8.

In the case of slot welds, the spacing (pitch) dimension follows the length dimension and is preceded by a hyphen, Figure 15.9. The spacing may also be shown by means of a detail drawing.

Depth of filling is shown within the symbol for both plug and slot welds. When not shown, complete filling is required, Figure 15.10.

Note that in all cases the dimensions applied to the plug and slot weld symbol are located on the same side of the reference line as the symbols. A combined use of dimensions for a plug weld symbol is shown in Figure 15.11, and for a slot weld in Figure 15.12.

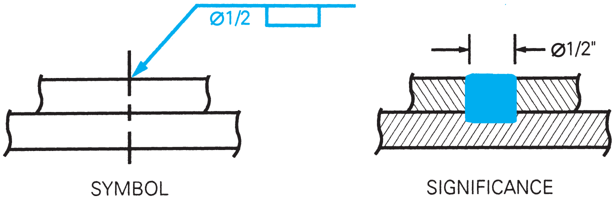


FIGURE 15.4 ■ Size of plug weld.

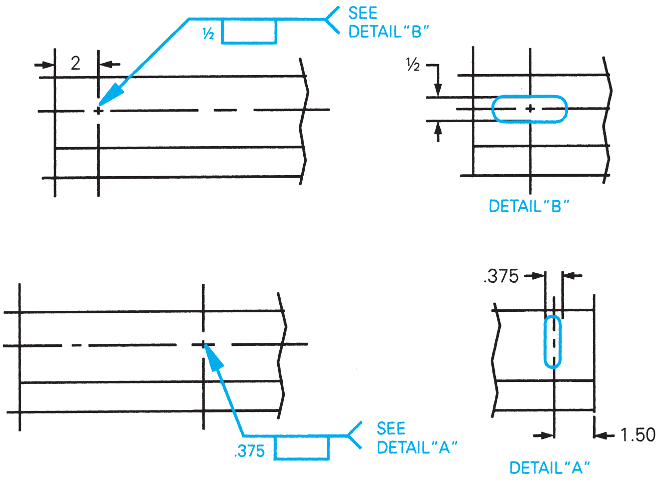
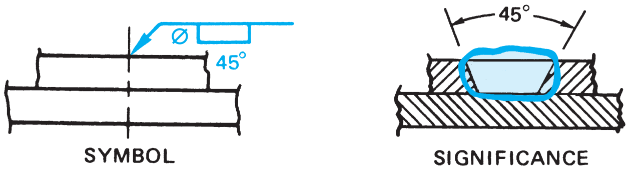
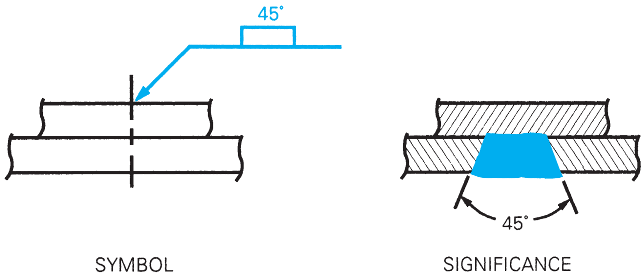


FIGURE 15.5 ■ Width and orientation of a slot weld by reference to a detail drawing.



(a) PLUG



(b) SLOT

OTHER SIDE

FIGURE 15.6(a, b) ■ Application of included angle dimension to plug and slot weld symbols.

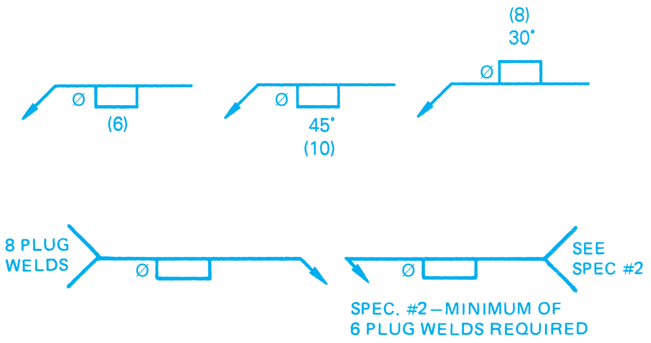


FIGURE 15.7 ■ Number of plug welds.

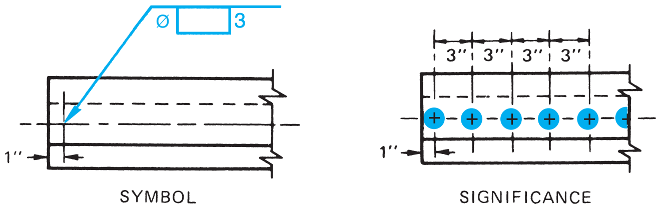


FIGURE 15.8 ■ Pitch of plug welds.

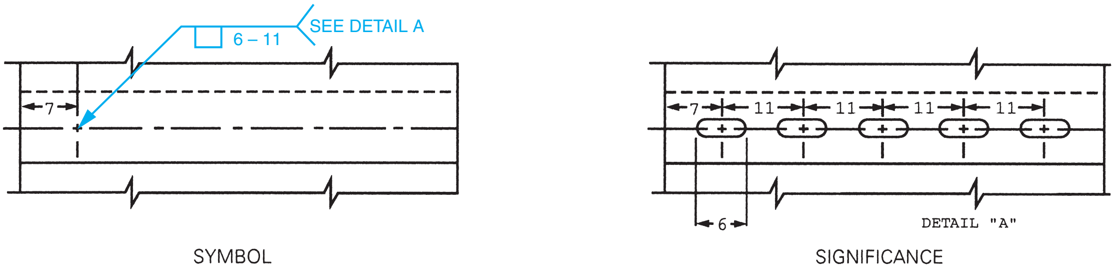


FIGURE 15.9 ■ Length and pitch of slot welds.

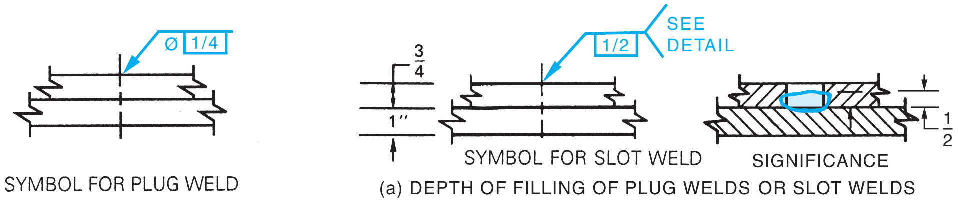


FIGURE 15.10 ■ Depth of filling of plug or slot welds.

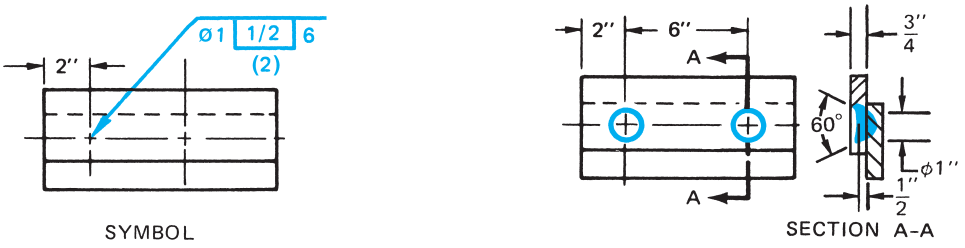


FIGURE 15.11 ■ Combined use of dimensions for a plug weld symbol.

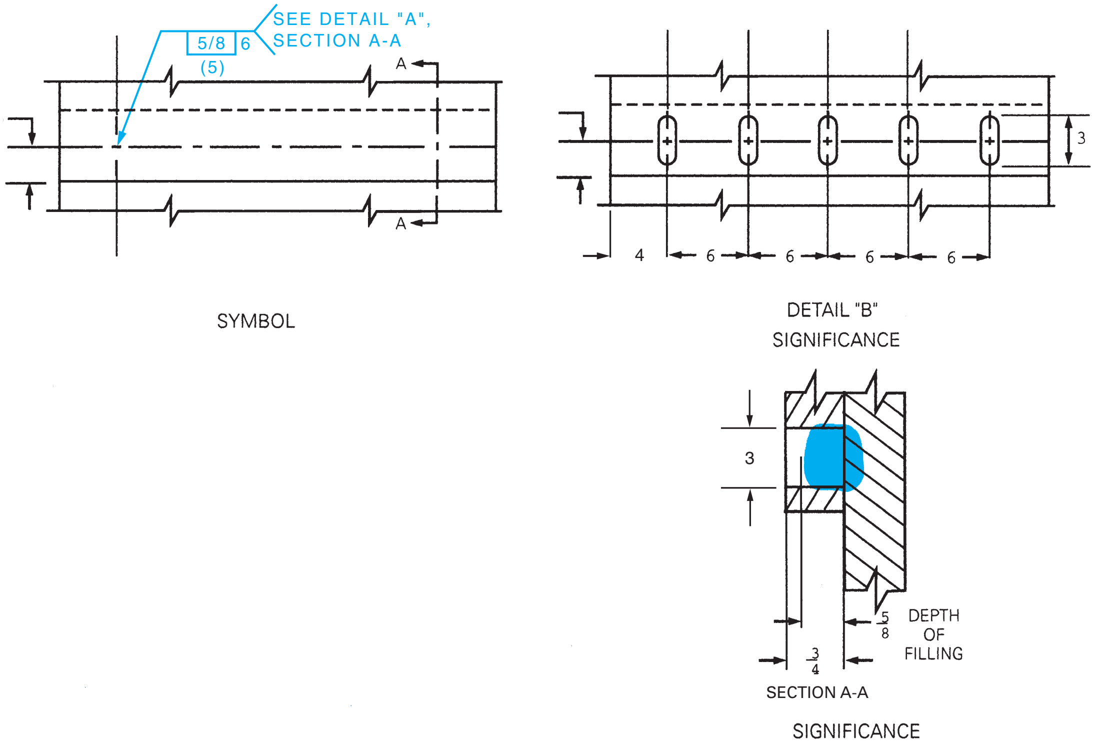


FIGURE 15.12 ■ Combined use of dimensions for a slot weld symbol.

CONTOUR AND FINISHING

Plug and slot welds are generally finished with a flush or convex contour. When a specific contour symbol is required, the appropriate contour symbol is shown above or below the weld symbol depending on its arrow side, or other side significance, Figure 15.13. If a method of postweld finish is also to be specified, it is placed above or below the contour symbol, Figure 15.13. In the case of a flat finish requirement, it is so specified by a note in the tail of the welding symbol, whereas a note for a flush finish is not needed.

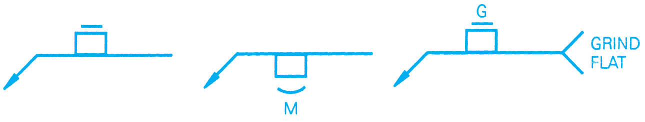


FIGURE 15.13 ■ Application of contour and finishing symbols.

PLUG WELDS WITH THREE OR MORE JOINTS

Two or more members may be welded to another member by means of a plug weld. When this is specified, the joint or joints to be welded are shown by a section drawing. The section drawing shows the member or members that will require joint preparation, Figure 15.14(a) and (b). Note the variation on the preparation required.

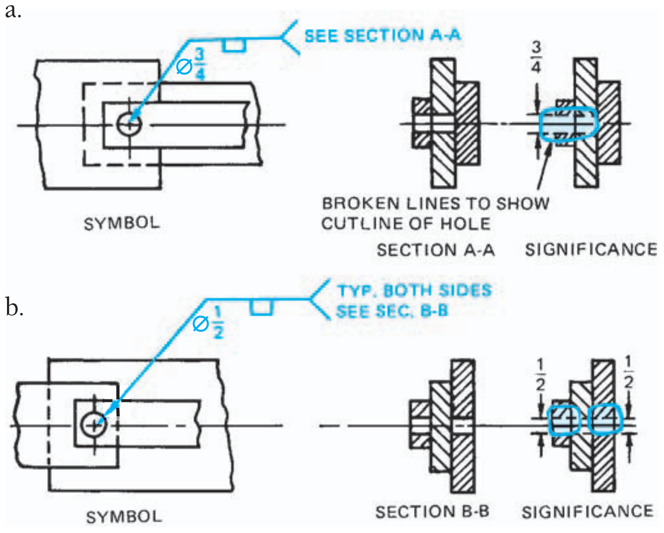


FIGURE 15.14 ■ Plug welds in a three-member assembly.

UNIT 15: REVIEW

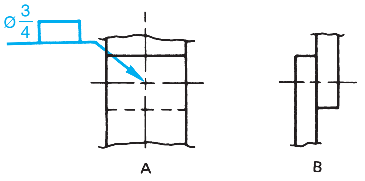
Graph paper is provided at the end of this review for your use.

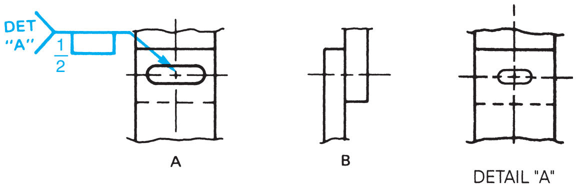
1. How does a slot weld differ from a plug weld?

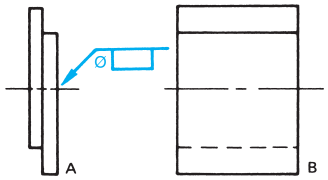
____

____

2. Show the desired welds called for in sketch A in sketch B.







3. To what part of the hole does the size of a plug weld refer?

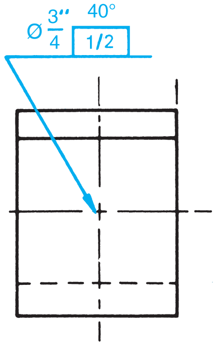
____

4. Where on the welding symbol is the size of a plug weld shown?

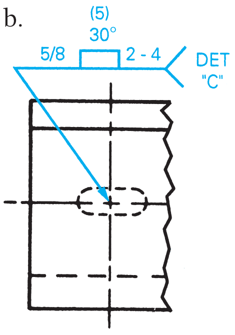
____

5. List all information supplied by the welding symbols shown.

a.



b.



a. ______________________________

____

____

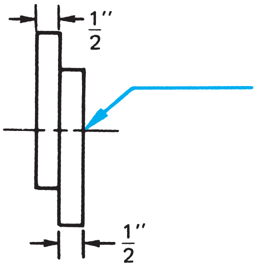
b. ______________________________

____

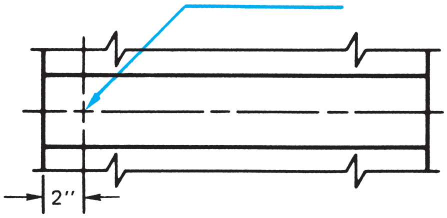
____

6. a. Complete the following welding symbol to indicate a ¾″ plug weld with a 60° angle of countersink on the other side of the joint, a 4″ pitch, and ⅜″ depth of fill.

   b. Sketch how the weld would appear on the drawing.



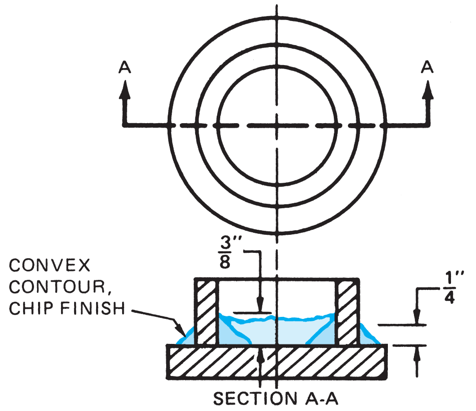
7. Complete the following welding symbol to indicate three 1″ plug welds on the arrow side member of the joint with 6″ pitch, ½″ diameter, and 60° countersink.



8. When is depth of filling not shown on the welding symbols for plug and slot welds?

____

9. Apply the correct symbol or symbols to the top view for the welds shown in the section view.



10. Interpret fully the welds specified on the design of the Building Girder.

Ⓐ ______________________________

Ⓑ ______________________________

Ⓒ ______________________________

Ⓓ ______________________________

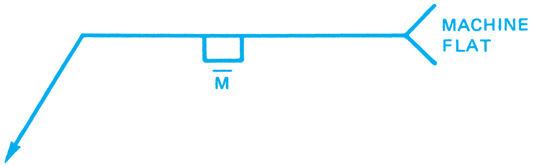
Ⓔ ______________________________

Ⓕ ______________________________

Ⓖ ______________________________

11. a. What is the purpose of including the note shown in the tail of the following welding symbol?

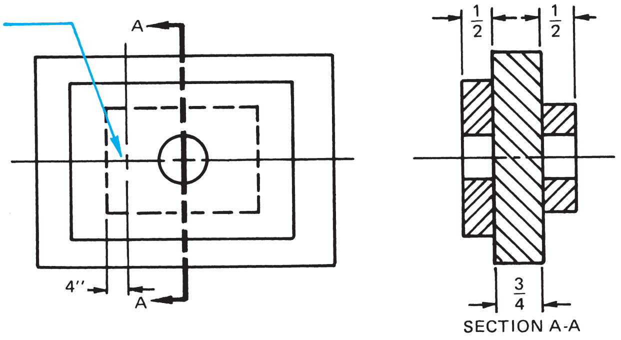
____

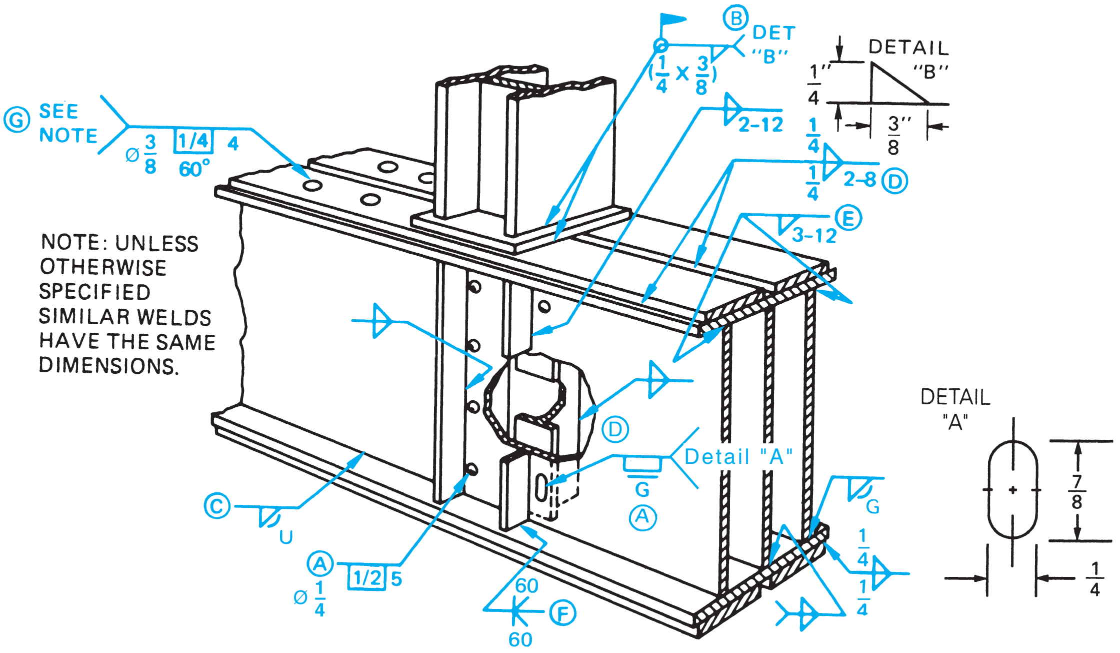


b. If the note were not included, what would be the required finish?

____

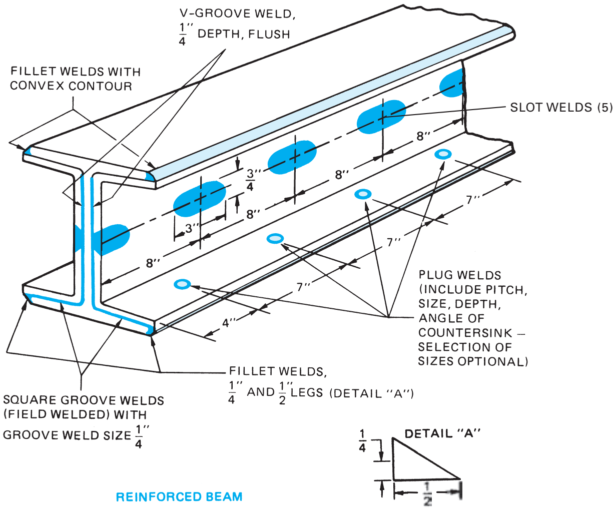
12. Complete the following welding symbol to indicate six ¾″ plug welds having a ½″ depth of filling with a 3″ pitch to join three members of a fabrication as shown in the following drawing.





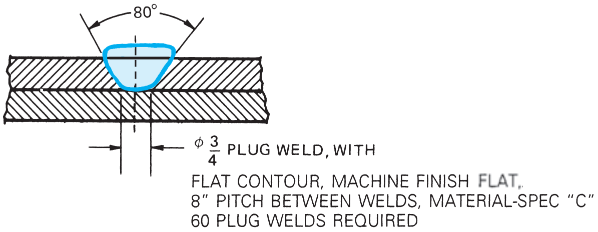
BUILDING GIRDER

13. Prepare a two-view sketch, front and side views, of the reinforced beam. Include all welding symbols necessary to describe the welds. Include weld details and dimensions where necessary.

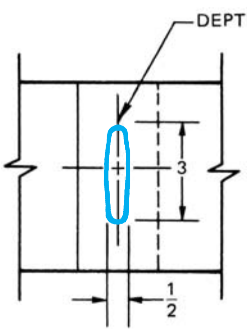


REINFORCED BEAM

14. Sketch the welding symbol that will indicate the following plug weld.


80°
φ 3/4 PLUG WELD, WITH
FLAT CONTOUR, MACHINE FINISH FLAT,
8" PITCH BETWEEN WELDS, MATERIAL-SPEC "C"
60 PLUG WELDS REQUIRED

15. Apply the welding symbol that will indicate the following slot weld.



UNIT 16

Surfacing Welds

A surfacing weld is used to build up a surface to (1) correct the size of a part, (2) provide a transition between dissimilar metals, (3) provide a corrosion resistant surface, or (4) provide a wear-resistant surface, and (5) reduce excessive root openings. Surfacing welds can be applied to a flat or contoured surface and are shown on the lower side of the reference line. Because this symbol does not refer to a joint, it has no arrow side or other side significance, Figure 16.1.

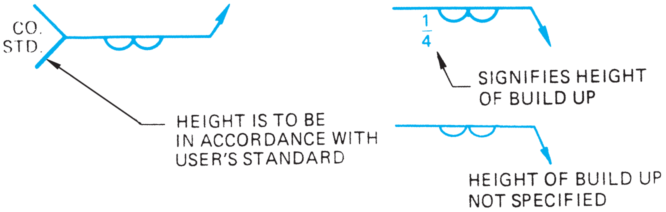


FIGURE 16.1 ■ Symbol for a built-up surface.

When the entire surface is to be built up, whether it be the entire area of a plane or curved surface, only one element may be added to the surface symbol. This element is the minimum thickness of the buildup of the weld deposit, which is shown to the left of the symbol, Figure 16.1. When a specific height is not desired, a dimension is not given. However, a reference in the tail of the welding symbol may be included to indicate a buildup in accordance with company standards.

For a completely built-up surface, the weld symbol may appear on a print as in Figure 16.2.

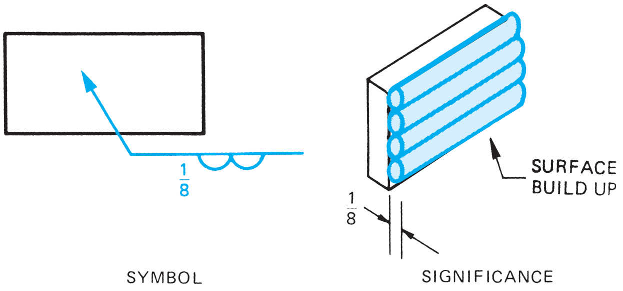


FIGURE 16.2 ■ Symbol indicating full surface buildup.

When only a portion of the surface must be built up, whether it be the area of a plane or curved surface, the extent, location, and orientation of the area to be built up is shown on the print in addition to the symbol, Figure 16.3(a). The direction of welding may also be indicated by a note in the tail of the welding symbol, Figure 16.3(b) and (c).

In cases where a surfacing weld is to be performed over another weld, a welding symbol with a multiple reference line may be used. For example, a fillet or groove weld may be the first operation, followed by the surfacing weld, Figure 16.4.

Differences in the direction of multiple surface welds may be indicated by the use of appropriate notes in the tail of the welding symbol, Figure 16.5(a).

Also, special applications of surface welds may be indicated by a note in the tail of the welding symbol, such as adjusting the fit-up of grooved joints, Figure 16.5(b).

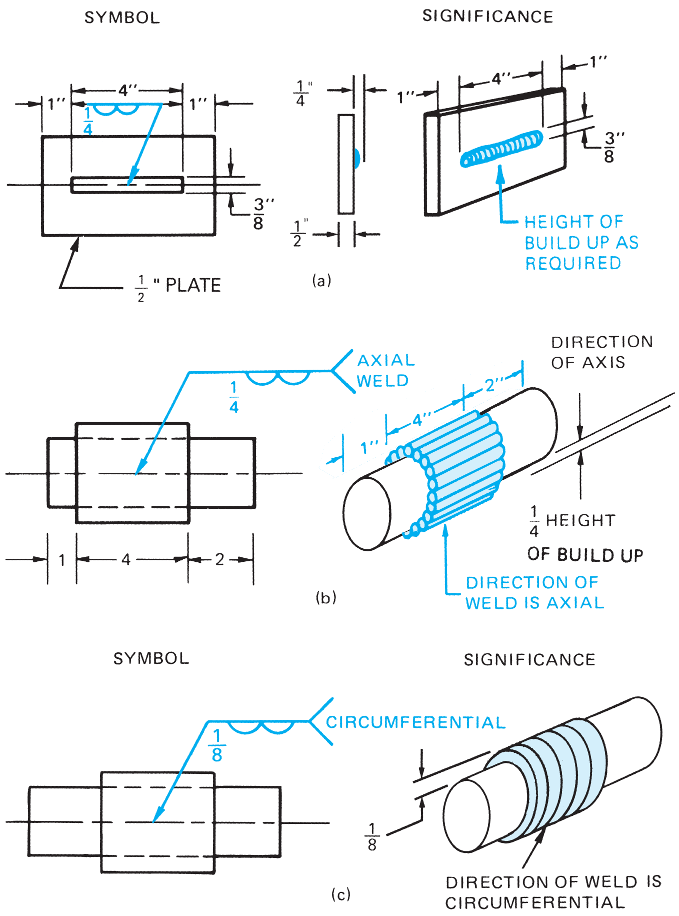


FIGURE 16.3 ■ Length, width, and direction of surface built up by welding.

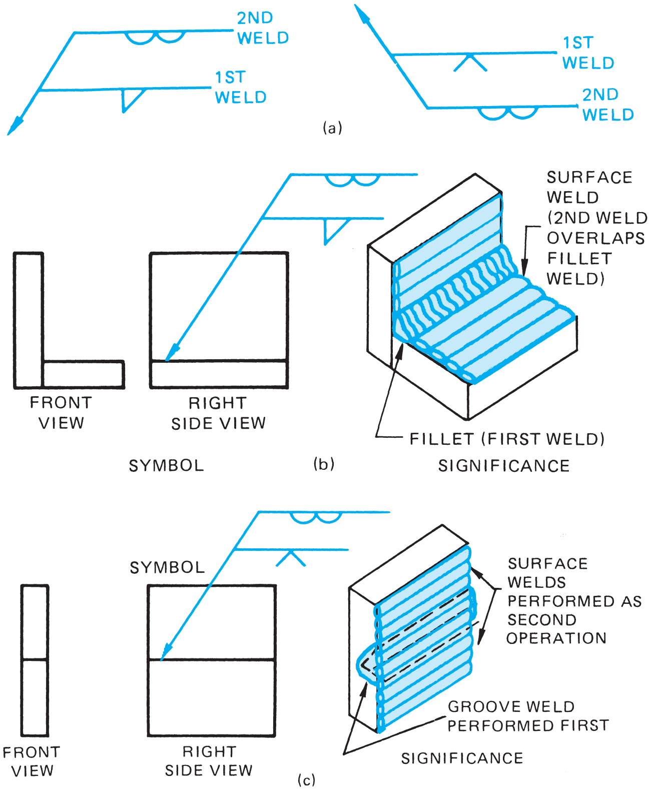


FIGURE 16.4 ■ Applications of surface weld symbol with other weld symbols using a multiple reference line welding symbol.

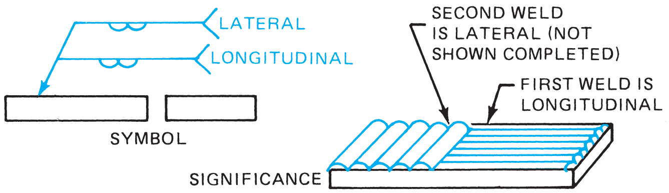

LATERAL
LONGITUDINAL
SYMBOL
SECOND WELD IS LATERAL (NOT SHOWN COMPLETED)
FIRST WELD IS LONGITUDINAL
SIGNIFICANCE

FIGURE 16.5(a) ■ Multiple-layer (longitudinal and lateral) surface welds.

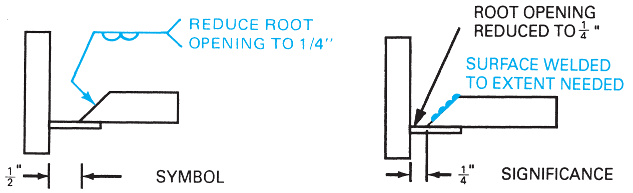
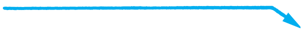

REDUCE ROOT OPENING TO 1/4″
1/2 ″
SYMBOL
ROOT OPENING REDUCED TO 1/4 ″
SURFACE WELDED TO EXTENT NEEDED
1/4 ″
SIGNIFICANCE

FIGURE 16.5(b) ■ Application of surface weld for reducing root opening of a bevel groove joint.

UNIT 16: REVIEW

Graph paper is provided at the end of this review for your use.

1. a. Complete the following welding symbol to indicate the building up of a surface.



   b. Apply and identify an element used with this symbol.

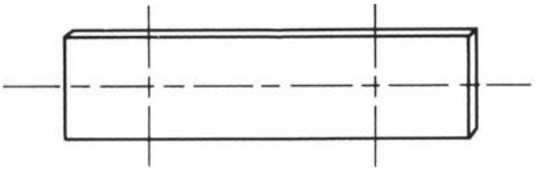
   c. On which side of the reference line is the weld symbol placed?

2. a. Does this symbol have an arrow side, other side significance?

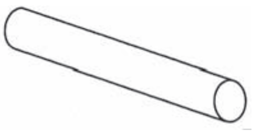
   b. Give the reason for your answer.

3. a. Show how the extent of the surfacing weld is indicated between the vertical centerlines in the following illustration.

   b. Show how a 1½″ weld width is indicated with a ½″ surface buildup.



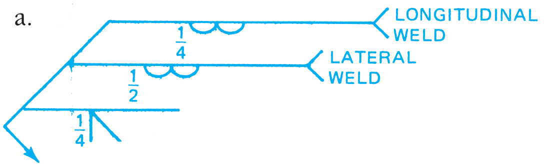
4. a. Illustrate an axial weld direction on the following sketch of a round rod to a ½″ surface buildup.



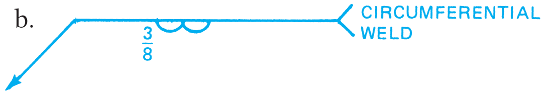
   b. Draw the welding symbol to specify this.

5. Explain the significance of the following welding symbols.

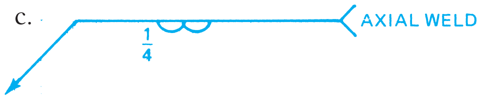
   a.



   b.

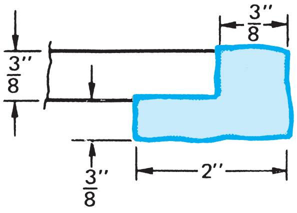


   c.

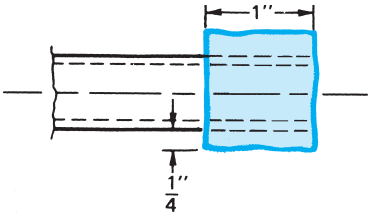


6. Draw the symbol for the following. Use a suitable sketch for applying the symbol.

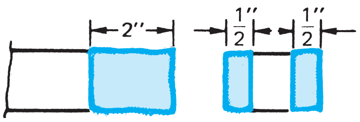
   a.



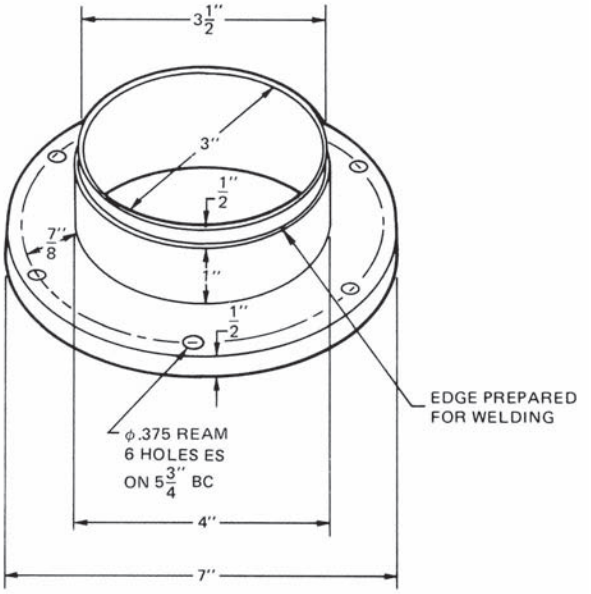
   b.



   c.



7. Illustrated is a hub cap punch prepared for welding and in finished form. The operation is to be done by building up with a surface weld to the desired height and machining the contour to match the 4″ diameter. Allow ⅛″ for finishing the welded surface. The surface is to be welded circumferentially. Make a two-view working sketch including dimensions and necessary welding symbols to specify the required work.



HUB CAP PUNCH

8. a. Interpret the note specifying reamed holes.

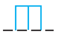
b. What is the spacing of the hole in degrees?

9. a. Draw a welding symbol that specifies a circumferential surface weld with no buildup size requirement.

b. Prepare a sketch that illustrates how the weld would appear.

UNIT 17

Edge Welds

The edge weld symbol  has replaced the flange butt and corner flange weld symbols, which have become obsolete. These former weld symbols are identified as joints to which the edge weld symbol is applied, Figure 17.1(a) and (b). Note that an edge weld symbol may also be applied to an edge joint, Figure 17.1(c).

The edge weld symbol is used particularly for sheet metal joinery (welding metal 3/16″ or less in thickness). It may be shown having an arrow side, other side, or both sides significance, Figure 17.2(a) and (b). It has a both sides application only to an edge joint. When so used, the symbols are placed opposite each other on the reference line, Figure 17.2(c).

Dimensions that may be added to the edge weld symbol are size, length, and spacing (pitch of intermittent welds). The standard locations for these dimensions are shown in Figure 17.3.

In instances where the weld is to be the full length of the joint, no length dimension is required. However, when the weld is to be specified for a particular length, dimensions within the extension lines are used, Figure 17.4. Hatching lines may also be applied to a detail drawing to indicate lengths to be welded.

When specifying the length and spacing of intermittent edge welds, the dimensions are placed to the right side of the weld symbol. The first dimension represents the length of the weld and the second, separated by a hyphen, the pitch, Figure 17.5.

To specify a chain intermittent edge weld, the edge weld symbol is applied to the welding symbol as shown in Figure 17.6. Note that the edge welds are directly opposite each other, and the length and pitch dimensions are located to the right of the symbols on both sides of the reference line. Length is the first dimension followed by a hyphen (-) and then the pitch.

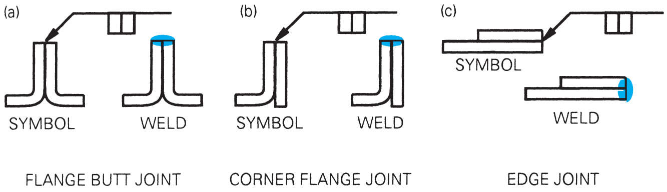


FIGURE 17.1 ■ Typical joints to which the edge weld symbol is applied.

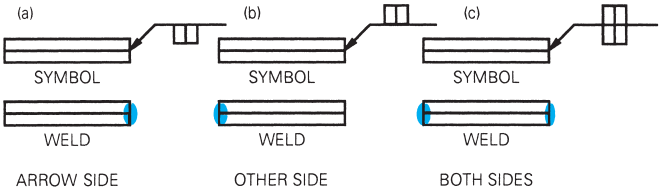
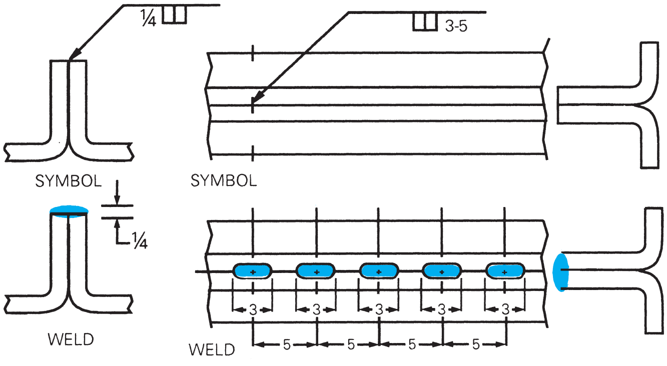


FIGURE 17.2 ■ Application of edge weld symbol to indicate arrow side, other side, and both sides welds.



3" LENGTH
5" PITCH
- HYPHEN USED TO SEPARATE DIMENSIONS

FIGURE 17.3 ■ Dimensions applied to the edge weld symbol.

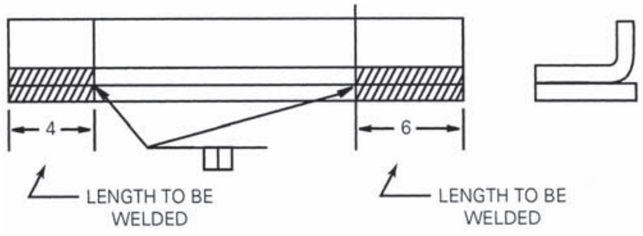


FIGURE 17.4 ■ Identifying sections to be welded by the use of hatching lines and dimensions within extension lines.

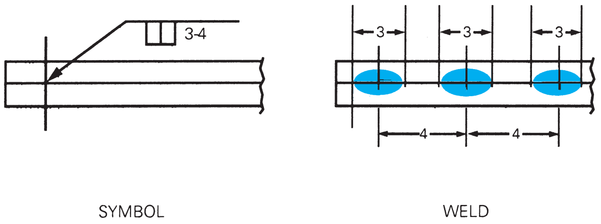


FIGURE 17.5 ■ Application of length and pitch dimensions to an edge weld symbol.

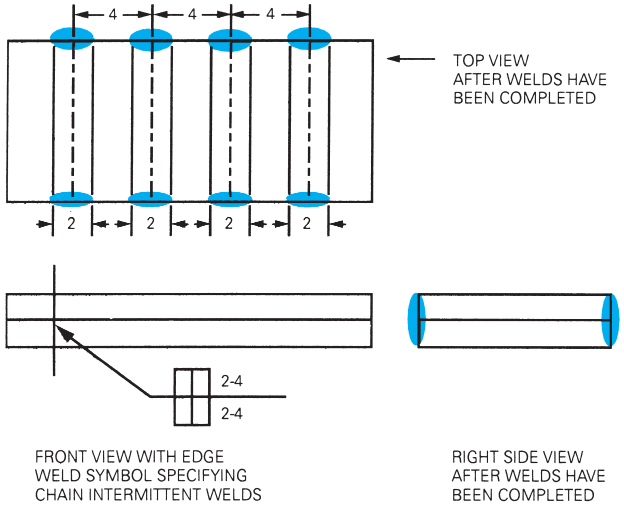

4
4
4
2
2
2
2
TOP VIEW AFTER WELDS HAVE BEEN COMPLETED
2-4
2-4
FRONT VIEW WITH EDGE WELD SYMBOL SPECIFYING CHAIN INTERMITTENT WELDS
RIGHT SIDE VIEW AFTER WELDS HAVE BEEN COMPLETED

FIGURE 17.6 ■ Chain intermittent edge welds.

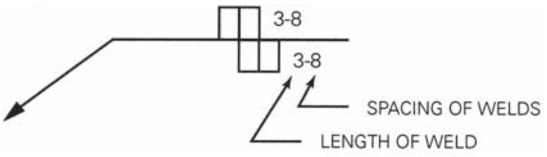


FIGURE 17.7 ■ Location of symbols for staggered intermittent edge welds.

For staggered intermittent edge welds, the edge weld symbol is shown offset, Figure 17.7 and Figure 17.8. Applicable length and pitch dimensions are placed on the right side of each symbol.

The edge weld symbol has the same application to multiple members of a flanged butt joint, flanged corner joint and edge joint consisting of more than two members, 17.9(a) and (b).

Other symbols that may be used in combination with the edge weld symbol are the melt-thru symbol ◖◗, the flare V-groove symbol)(, and the flare bevel groove symbol |(. The melt-thru symbol is added when complete joint penetration is to be specified, Figure 17.10. Note that in this process the joint loses its identity.

The flare V-groove and flare-bevel groove symbols are used in combination with the edge weld symbol to reinforce the welded joint, Figure 17.11 and Figure 17.12.

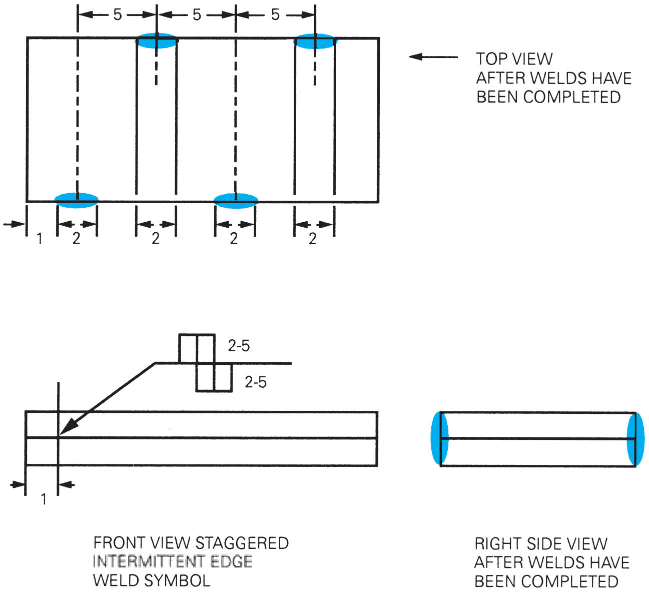

5
5
5
TOP VIEW AFTER WELDS HAVE BEEN COMPLETED
1
2
2
2
2
2-5
2-5
1
FRONT VIEW STAGGERED INTERMITTENT EDGE WELD SYMBOL
RIGHT SIDE VIEW AFTER WELDS HAVE BEEN COMPLETED

FIGURE 17.8 ■ Application of a staggered intermittent edge weld symbol.

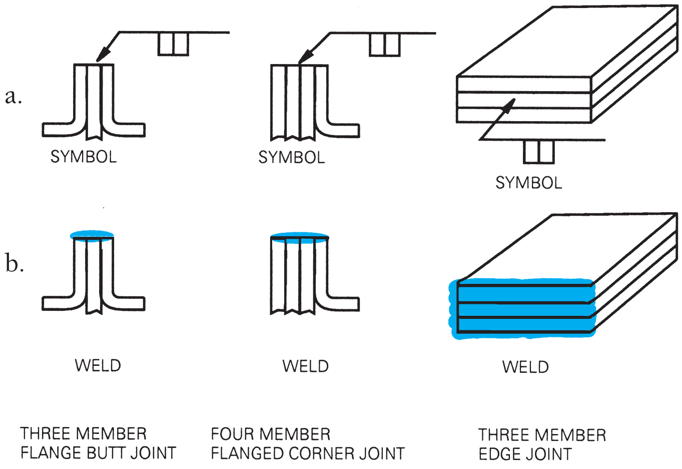

a.
SYMBOL
SYMBOL
SYMBOL
b.
WELD
WELD
WELD
THREE MEMBER FLANGE BUTT JOINT
FOUR MEMBER FLANGED CORNER JOINT
THREE MEMBER EDGE JOINT

FIGURE 17.9 ■ Application of edge weld symbol to joints consisting of more than two members.

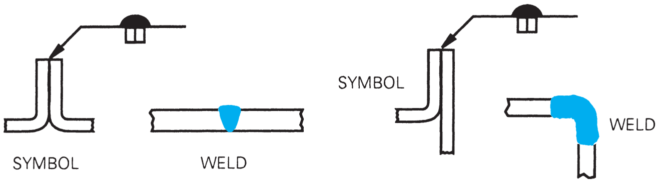


FIGURE 17.10 ■ Combination edge weld and melt-thru symbol.

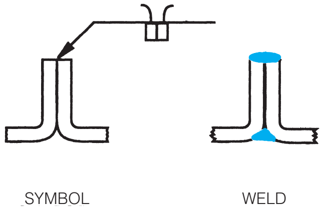


FIGURE 17.11 ■ Combination edge weld and flare V-groove symbol.

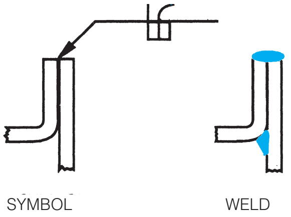


FIGURE 17.12 ■ Combination edge weld and flare bevel groove symbol.

To summarize, the edge weld symbol has many of the elements applied to other weld symbols—size, length, pitch, weld-all-around, weld-in-field, finishing and methods of finishing welds. It is applied to flange-butt, flanged corner, and edge joints, and may be used in conjunction with melt-thru, flare-groove, and flare-bevel symbols.

UNIT 17: REVIEW

Graph paper is provided at the end of this review for your use.

1. a. Identify three joints to which an edge weld symbol may be applied.

   b. Sketch examples of these joints.

   c. Apply the edge weld symbol with an arrow side significance to each of these joints.

2. Sketch how the edge weld symbol would be shown for an intermittent other side edge weld. Use a welding symbol for this purpose.

3. a. What other weld symbols may be used in conjunction with the edge weld symbol?

   b. Sketch combination edge weld symbols to include the other weld symbols identified in 3(a).

4. a. List three dimensions that may be applied to an edge weld symbol.

   b. Sketch a welding symbol with an edge weld that includes the standard locations for these dimensions.

   c. Identify each dimension on the sketch.

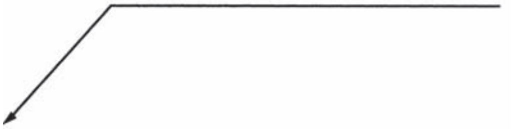
5. Sketch welding symbols that include an edge weld symbol having the following elements:

   Convex contour
   Concave contour
   Flush or flat contour
   Weld-all-around
   Machine flat
   Planish flat

6. Sketch a welding symbol that includes an edge weld symbol applied to extension and hatching lines to show the location and extent of an edge view.

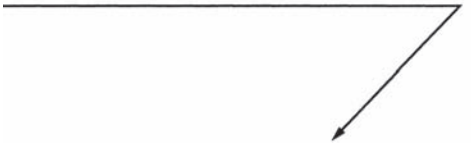
7. Complete the following symbols to show:

   a. A chain intermittent edge weld.



   b. A staggered intermittent edge weld.

   c. A weld-all-around edge weld including finish and method of finish.



8. a. Identify the joints that lose their identity upon completion of an edge weld when complete penetration is specified.

   ____

   ____

   ____

   b. Using sketches, illustrate the joints and their appearance identified in 8(a) upon their completion.

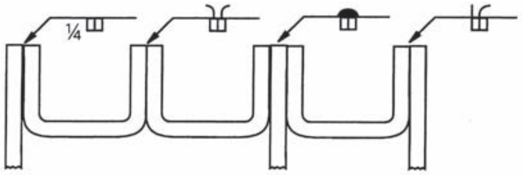
   c. Complete the following welding symbol to indicate an edge weld requiring complete penetration.

9. Up to what metal thickness size is an edge weld symbol usually applied?

   ____

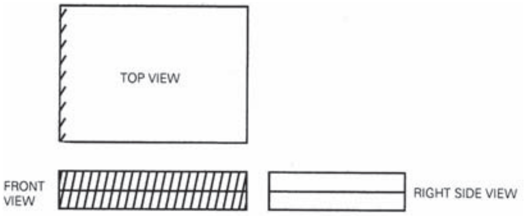
   ____

10. On the drawing that follows, sketch how the completed weld will appear as indicated by the weld symbols.



11. Sketch a welding symbol to specify a both sides edge weld with a ⅛″ thickness on an edge joint.

12. In the following drawing, edge welds are to be specified for the edges identified by hatched lines. Apply the appropriate symbol(s).



18 UNIT

Spot Welds

A spot weld is made between or on overlapping members of a joint. In cross section, the spot weld appears to be circular. The symbol for a spot weld is ◯. This symbol is similar to the weld-all-around symbol except that it is centered on the reference line. (Note that the weld-all-around symbol is placed at the break in the reference line, ○—.)

The spot-weld symbol is located tangent to the reference line (circumference of symbol touches line) when it has an arrow side or other side significance. It is centered on the reference line when there is no arrow side or other side significance, Figure 18.1.

When the spot weld is used, the tail must always be included. The welding process reference required as one of the elements of the symbol is placed in the tail. (See Unit 10 for the meanings of the abbreviations for the various welding processes.)

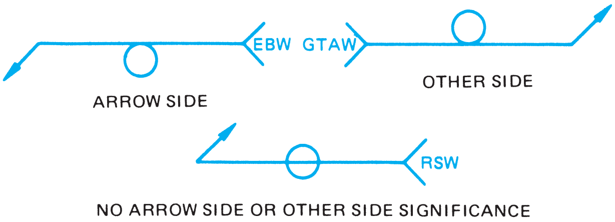


FIGURE 18.1 ■ Location of spot-weld symbol.

DIMENSIONING THE SPOT-WELD SYMBOL

Dimensions applied to the spot-weld symbol are shown on the same side of the reference line as the symbol, or on either side when there is no arrow side or other side significance for the symbol, Figure 18.2. Dimensions typically used with this symbol include the size or strength, spacing, extent, and the number of spot welds.

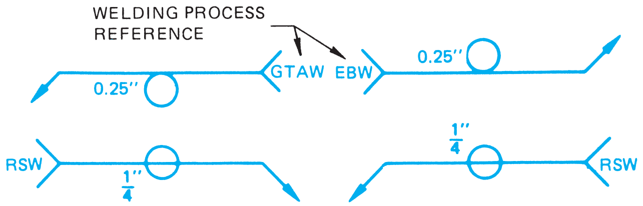


FIGURE 18.2 ■ Size of spot welds and welding process.

The size of a spot weld is shown to the left of the weld symbol. This dimension represents the diameter of the weld at the faying (joining) surfaces in fractions of an inch or in decimal fractions, with or without inch marks, Figure 18.2 and Figure 18.3. Note that the size dimensions are given in millimeters when the drawing is dimensioned in metric.

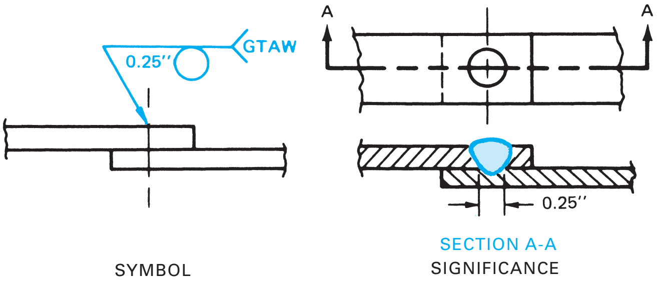


FIGURE 18.3 ■ Application of size dimension.

If the strength of the weld is to be given rather than its size, the value is placed to the left of the spot-weld symbol. An explanation of the meaning of this value appears as a note on the drawing, Figure 18.4. Either the size of the spot weld or the shear strength is specified on the welding symbol, but not both. The shear strength may be expressed in pounds or Newtons per spot. Newtons are used when the drawing dimensions are in metric. The letter "N" is added to the strength dimension to indicate Newtons, Figure 18.6.

The spacing of spot welds is indicated by a number placed to the right of the weld symbol. This number is called the pitch and refers to the center-to-center distance between the spot welds, Figure 18.5 and Figure 18.6.

When the spot welding extends the full distance between decided changes in the direction of welding, or the full length of the joint, no dimension is given for the extent of welding. When the extent of welding is less than the full length of the joint or the full distance for one direction of welding, the extent dimension is shown directly on the drawing, Figure 18.7.

The number of spot welds in a joint is indicated on the symbol in parentheses. The number is placed below the weld symbol when it has an arrow side significance. It is placed above the symbol when it has an other side significance, Figure 18.8. When the symbol is located astride (centered on) the reference line, the dimension can be placed on either side of the reference line, Figure 18.8.

When a pattern for the application of the spot welds is not specified, the welding symbol and elements are drawn as in Figure 18.9(a).

When a group of spot welds may be conveniently located by dimensioning intersecting center lines on a drawing, they are shown as illustrated in Figure 18.9(b). Note that multiple arrows are used, and that they touch the centerlines that show the weld locations.

The dimension for the center-to-center spacing (pitch) of spot welds is shown to the right of the weld symbol, Figure 18.10. When the symbol is centered on the reference line, the dimension can be placed on either side of the reference line.

The use of combined dimensions is shown in Figure 18.11.

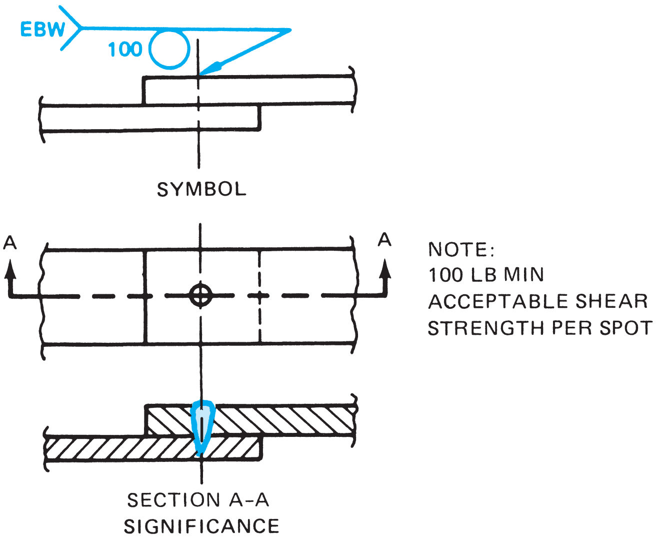


FIGURE 18.4 ■ Application of shear strength dimension to the spot-weld symbol.

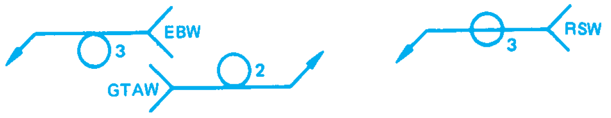


FIGURE 18.5 ■ Application of spacing (pitch) dimension.

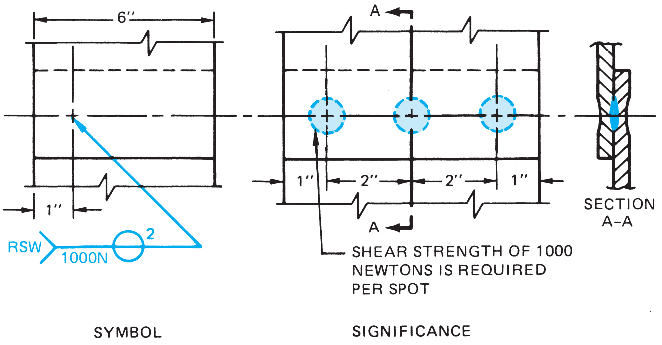


FIGURE 18.6 ■ Application and interpretation of spacing (pitch) dimension.

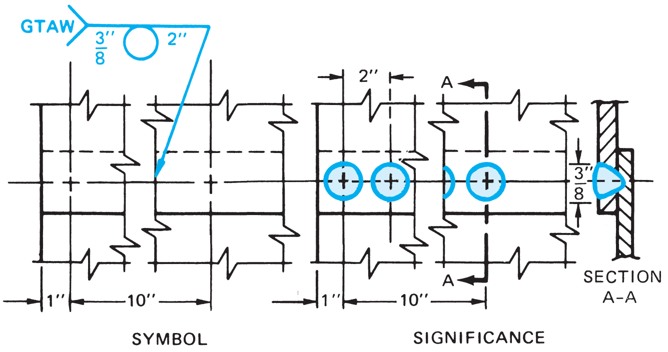


FIGURE 18.7 ■ Extent of spot welding.

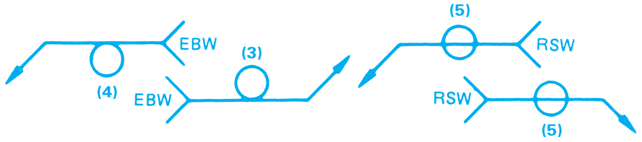


FIGURE 18.8 ■ Number of spot welds.

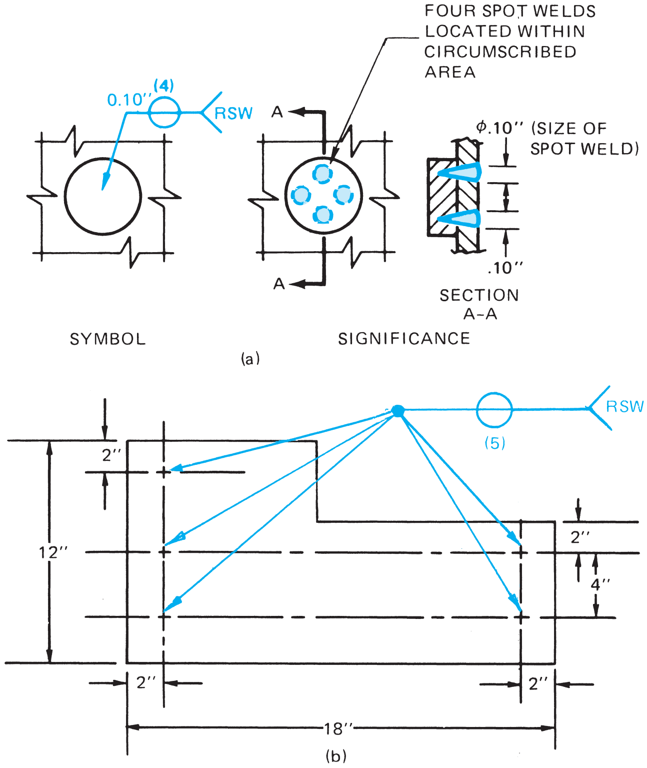

0.10″
(4)
RSW
A
A
FOUR SPOT WELDS LOCATED WITHIN CIRCUMSCRIBED AREA
ϕ.10″ (SIZE OF SPOT WELD)
.10″
SECTION A–A
SYMBOL
SIGNIFICANCE
(a)
RSW
(5)
2″
12″
2″
4″
2″
2″
18″
(b)

FIGURE 18.9 ■ Spot welds (a) located at random and (b) located by dimensioning.

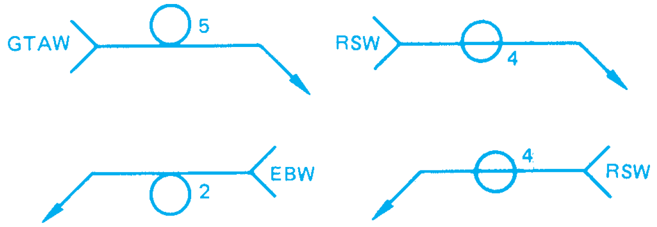


FIGURE 18.10 ■ Indicating pitch with the spot-weld symbol.

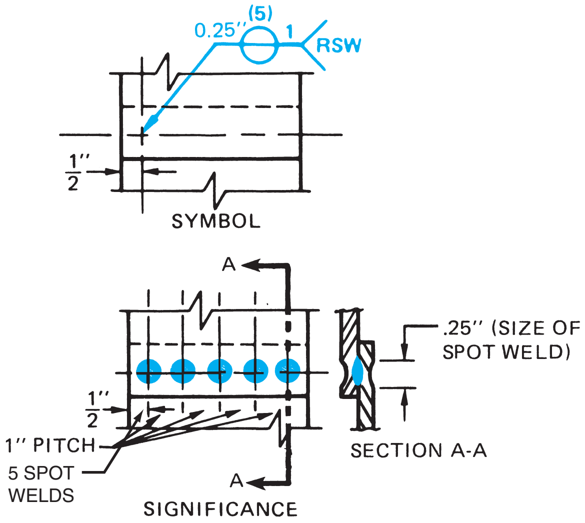


FIGURE 18.11 ■ Spot-welding symbol showing the use of combined dimensions.

CONTOUR AND FINISH SYMBOLS

The flat or flush-contour symbol and method of finish may be added to the spot-weld symbol when the exposed surface of either member of the spot-welded joint is to be made flush or flat, Figure 18.12 and Figure 18.13. Note that a machine finish may be specified as flat without a need for it to be flush by adding a note in the tail "machine flat," Figure 18.12.

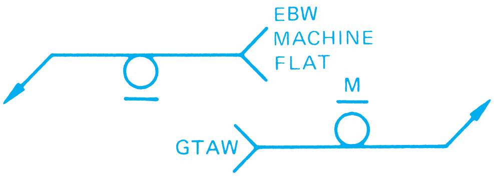
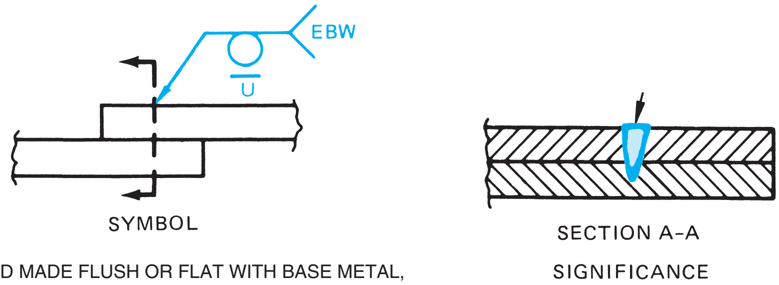


FIGURE 18.12 ■ Flush-contour symbol.



WELD MADE FLUSH OR FLAT WITH BASE METAL,
METHOD OF FINISH UNSPECIFIED

FIGURE 18.13 ■ Application of flush- or flat-contour symbol.

Multiple-Member Spot Welds

Multiple-joint spot welds include one or more pieces inserted between the two outer members. The same spot-weld symbol and the same elements are applied in this case as for a two-member joint, Figure 18.14.

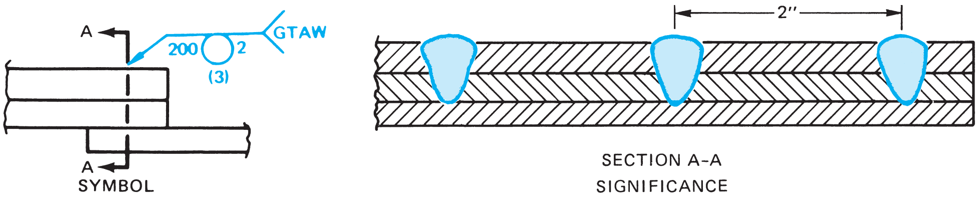


FIGURE 18.14 ■ Multiple-member spot welds.

UNIT 18: REVIEW

Graph paper is provided at the end of this review for your use.

1. Using sketches, show how the spot-weld symbol differs from the weld-all-around symbol.

2. On what side of the reference line are dimensions applied to the spot-weld symbol?

   ____

3. Is it necessary to use a tail with the spot-weld symbol?

   ____

   Explain.

   ____

4. What does the term pitch refer to when applied to the spot-weld symbol?

   ____

   ____

   ____

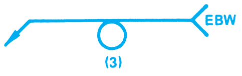
5. List five dimensions or other information that may be applied to the spot-weld symbol.

   ____

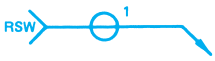
   ____

   ____

6. Identify the dimension shown with each of the following spot-weld symbols:



____



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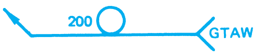
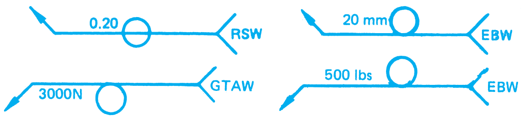


____

7. Give the significance of each dimension shown in the following symbols.



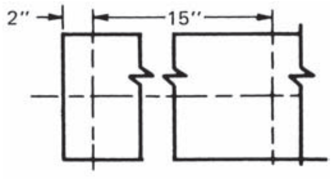
   a. .20″ ______________________________

   b. 20 mm ______________________________

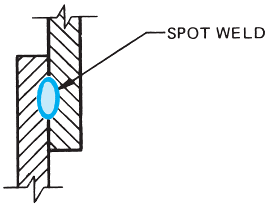
   c. 3000 N ______________________________

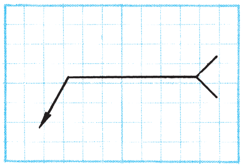
   d. 500 lbs ______________________________

8. Apply a welding symbol to the following sketch to indicate seven spot welds on the horizontal centerline between the 15″ dimension, spaced 2½″ apart, size of spot weld to be ¼″, and the process to be resistance spot welding.

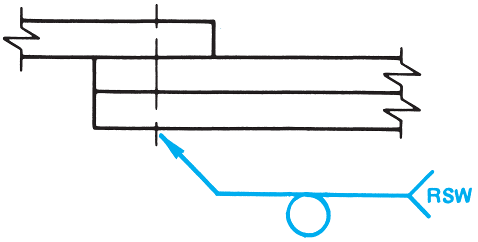


9. Show where the spot-weld symbol should be located on the reference line for the weld shown in the following sketch. Include an RSW process reference.

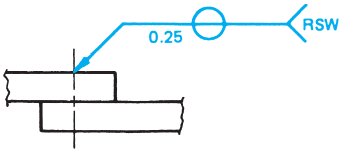


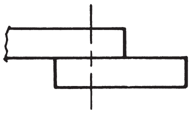


10. Sketch the weld called for by the following symbol.



11. a. Sketch the desired weld as indicated by the following welding symbol. Apply it to the sketch shown on the right.





b. On the sketch, show the significance of the 0.25 figure.

c. Identify the type of joint that is shown in the sketch.

d. If a figure of 200 lbs were shown in place of the 0.25, what would it signify?

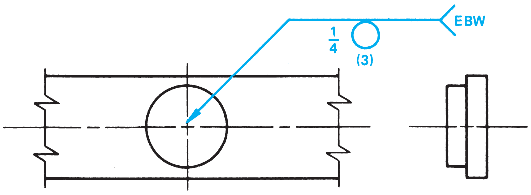
e. If a figure of 200N is shown, what does it signify?

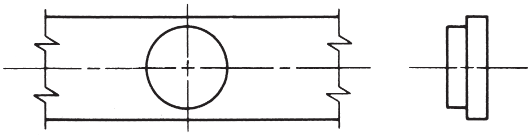
f. If a figure of 30 mm is shown, what does it signify?

12. a. Describe the locations of the required welds as they would appear in the sketch below.

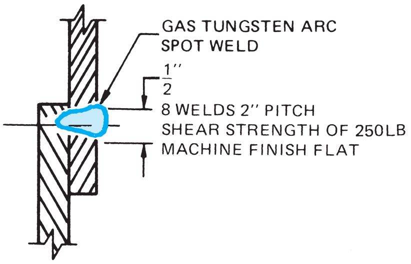
b. Indicate on the sketch below the location of the weld specified by the weld symbol given.

c. Indicate on the sketches below how the welds will appear.

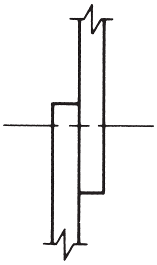




13. Apply the data for spot welds shown in Sketch "A" to Sketch "B" by means of a welding symbol.

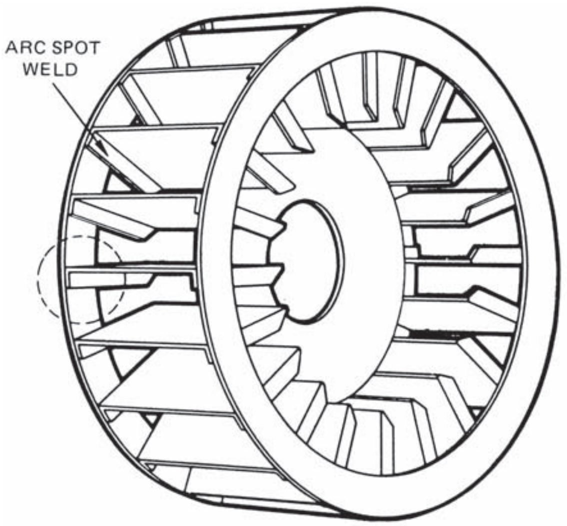


SKETCH "A"



SKETCH "B"

14. Sketch an enlarged detail of the portion of the fan rotor that is circled by a broken line. Apply a spot-weld symbol to this detail that signifies four spots 0.25″ diameter and spaced 1″ apart. The spot welds are to be made on the outside surface of the ring beginning ½″ from the outer circumference. Include an appropriate welding process reference on the welding symbol. Also indicate the spot welds that are to be finished flush by grinding.



UNIT 19

Projection Welds

A projection weld is a resistance type weld that is generally applied to a lap or edge joint. The welds to be made are localized at predetermined points and appear as projections or embossments, Figure 19.1. One of the members of the lapped joint is always prepared with an embossed (raised) surface for a projection weld, Figure 19.2. These regularly spaced projections, however, are not shown on any of the views of the drawing. The symbol for this weld is identical to the spot-weld symbol, ○, and can be applied to the reference line to denote either an arrow side or other side significance. It is not shown astride (centered on) the reference line.

The projection-weld symbol can be distinguished from the spot-weld symbol by the resistance welding process (PW) notation placed in the tail of the arrow. The letters “PW” in the process reference indicates that projection welds are to be made.

When the symbol has an arrow side significance, the embossment is located on the arrow side member, Figure 19.3. An other side significance means that the embossment is located on the other side member. Note that the welding process, PW, is *always* included in the tail for this particular weld.

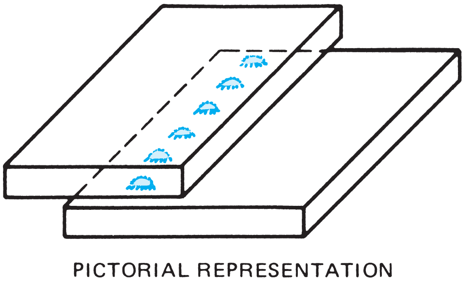


FIGURE 19.1 ■ Application of a projection weld to a lap joint.

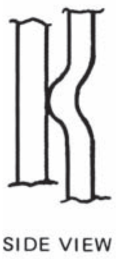


FIGURE 19.2 ■ Side view of a lap joint showing embossment preparation.

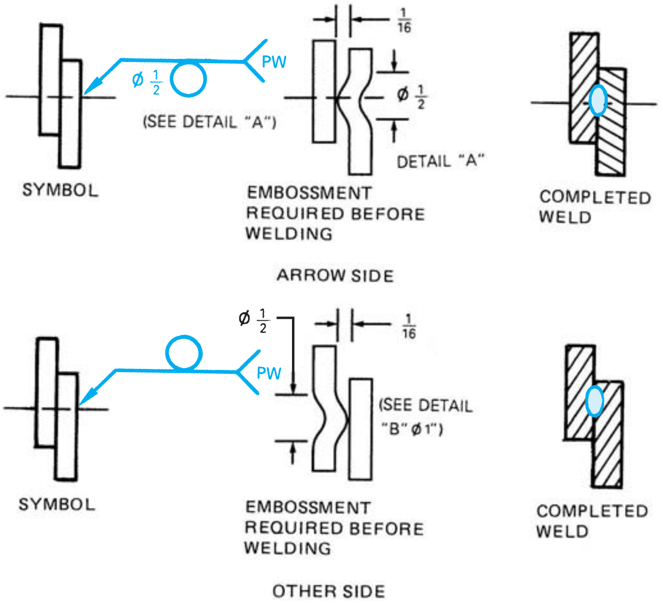


FIGURE 19.3 ■ Application of projection spot-weld symbol.

The elements that can be applied to the projection weld symbol are as follows:

- Sizes and strength of projection weld. Note the size dimension is preceded by the diameter symbol ∅. The strength size is followed by the abbreviation lbs and for metric, mm.
- Spacing of projection welds
- Extent of projection welds
- Number of projection welds
- Welding process

Several of these elements are applied to the welding symbol shown in Figure 19.4.

The welding symbol for a projection weld can also be used to show the extent of the projection welds. It can be incorporated on the drawing within two extension lines or two centerlines, as shown in Figure 19.5.

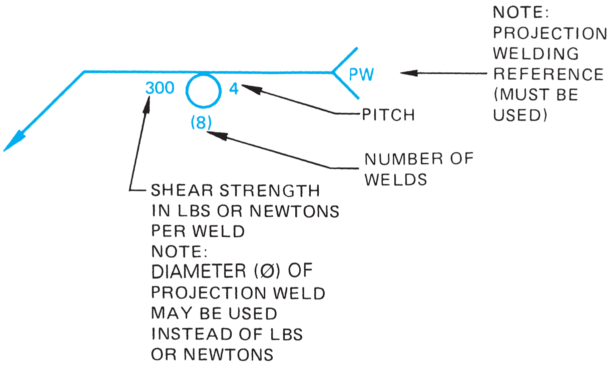


FIGURE 19.4 ■ Elements applied to the projection-weld symbol.

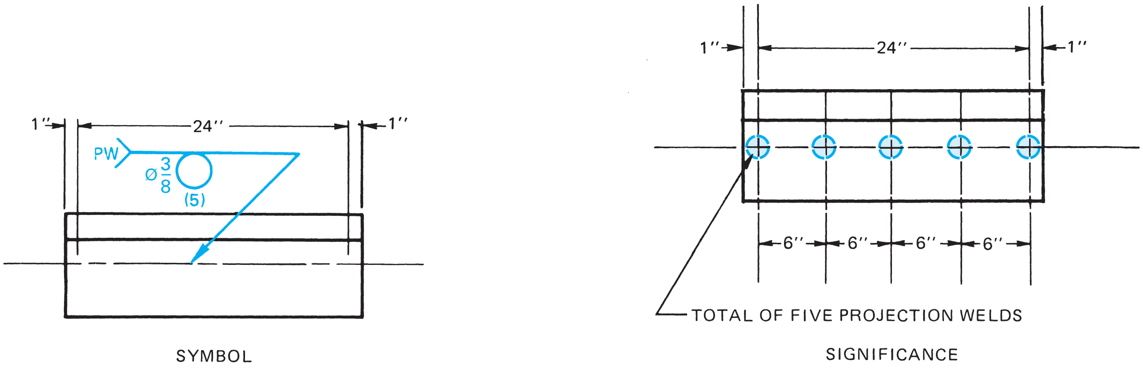
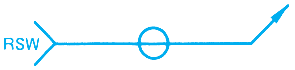


FIGURE 19.5 ■ Application of welding symbol to show extent of projection welds.

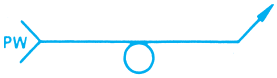
UNIT 19: REVIEW

1. a. Identify the following symbols.

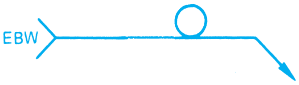
(1) ________



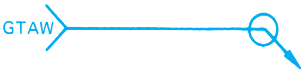
(2) ________



(3) ________



(4) ________



b. Which symbol or symbols in question 1(a) cannot be converted to a projection-weld symbol by changing the welding process?

____

2. List five elements that can be applied to a projection-weld symbol.

____

____

____

____

____

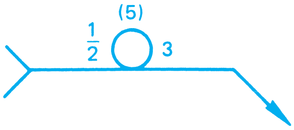
3. a. Identify each element given on the following projection-weld symbols (1 through 4).

b. Add the element(s) missing in each of the symbols.

(1) ________

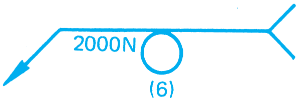
____

____



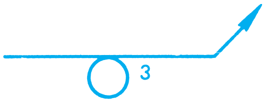
(2) ________

____



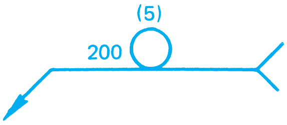
(3) ________

____



(4) ________

____



4. a. How does the joint preparation for a projection weld differ from that for a spot weld?

____

____

____

b. Prepare a sketch to illustrate this.

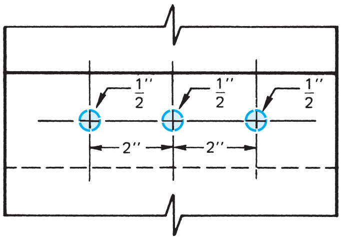
5. Where is the projection-weld symbol located on the reference line? How does this differ from spot-weld symbol locations?

____

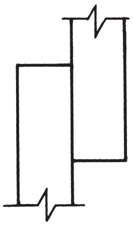
____

____

6. Apply a welding symbol to Sketch "B" that specifies the data shown in Sketch "A." Add any other elements necessary to indicate that it is a projection weld. Indicate on the symbol that there are to be three projection welds with ½″ diameters, spaced 2″ apart. Add any other elements necessary to indicate that it is a projection weld.



SKETCH "A"



SKETCH "B"

7. Is the projection-weld symbol used to denote a both sides significance? Explain.

____

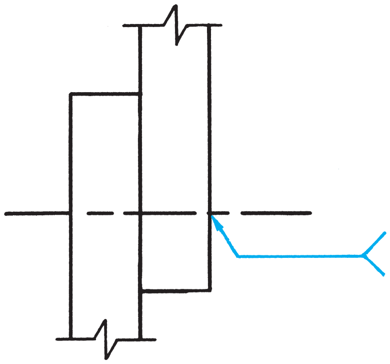
____

____

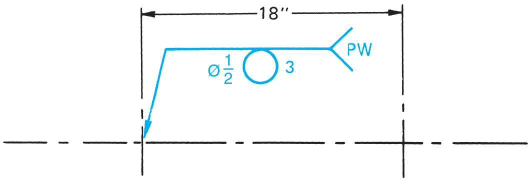
8. a. Locate the projection-weld symbol on the reference line of the welding symbol in the following sketch to indicate other side projection welds.

   b. Add the necessary elements to indicate that six projection welds are required.

   c. Add the element that specifies a shear strength of 200 pounds per projection weld.

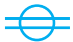


9. What is the significance of the welding symbol shown in the following illustration?



UNIT 20

Seam Welds

A seam weld is a continuous weld made on or between overlapping members of a joint. It is a continuous weld that may consist of a single weld or a series of overlapping spot welds. The seam-weld symbol, , may have an arrow side or other side significance, Figure 20.1(a) and (b). Because of the nature of the weld, the symbol is not used with a both sides significance. When an arrow side or other side significance is not intended, the seam-weld symbol is located astride the reference line, Figure 20.1(c). When the symbol is so shown, it indicates the weld is located between the members. A tail must be used with this symbol to indicate the process reference.

Dimensions that can be applied to the seam-weld symbol include:

- Size of the weld expressed in fractions or decimals of an inch (with or without inch marks) or in millimeters when the drawing is metric.
- Strength of the weld in terms of the shear strength of the weld in pounds per linear inch or in Newtons per millimeter. When expressed in Newtons, the letter "N" is added to the value.
- Extent of the weld.
- Center-to-center spacing (pitch) of the weld.

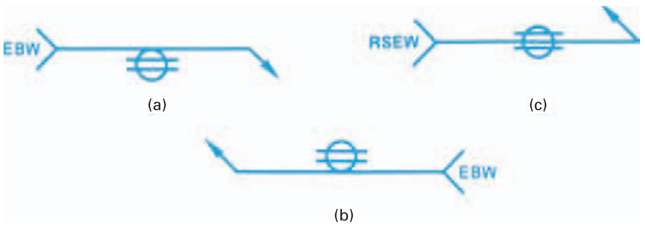
Dimensions are applied on the same side of the reference line as the weld symbol. When the symbol is located astride the reference line, the dimensions can be placed on either side of the reference line.

The size of a seam weld is placed to the left of the symbol and indicates the width of the weld, Figure 20.2.

The value for the strength of a seam weld is placed to the left of the symbol, and is used in place of the size dimension when the strength of the weld is a required specification, Figure 20.3 and Figure 20.4.

The dimension for the length or extent of a seam weld is placed to the right of the symbol, Figure 20.5. However, when the weld extends the full length of the joint, or when it extends the full distance between abrupt changes in the direction of welding, the length dimension is not necessary.

When the seam weld extends less than the full length of the joint, or less than the distance between abrupt changes in the direction of welding, the extent of the weld is shown, Figure 20.6 and Figure 20.7.



(a) (c)

(b)

FIGURE 20.1 ■ Seam-weld symbol with process reference.

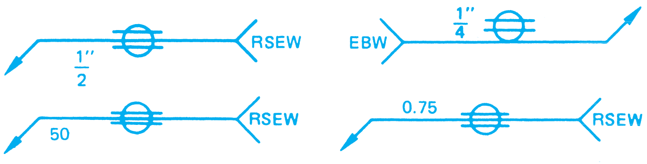


FIGURE 20.2 ■ Size of a seam weld.

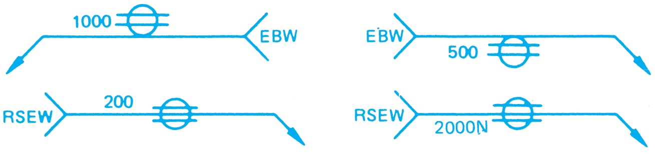


FIGURE 20.3 ■ Strength of a seam weld.

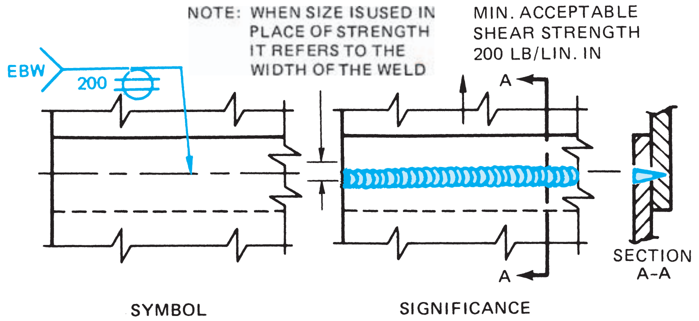

NOTE: WHEN SIZE IS USED IN PLACE OF STRENGTH IT REFERS TO THE WIDTH OF THE WELD
MIN. ACCEPTABLE SHEAR STRENGTH 200 LB/LIN. IN
EBW
200
A
A
SECTION A–A
SYMBOL
SIGNIFICANCE

FIGURE 20.4 ■ Application of the strength dimension to a seam-weld symbol.

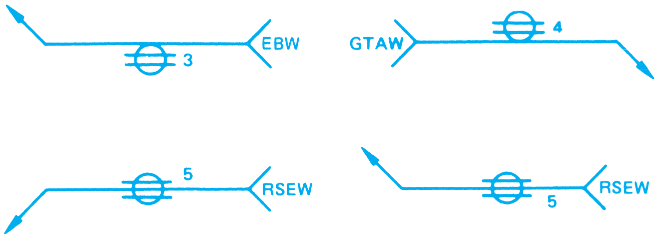


FIGURE 20.5 ■ Length of seam welds.

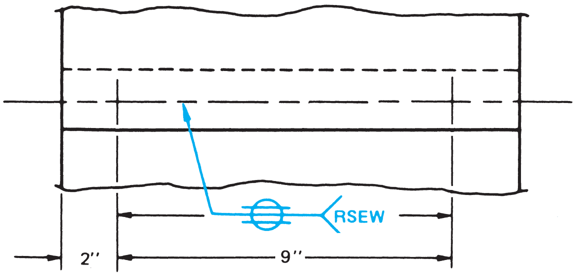


FIGURE 20.6 ■ Method for showing extent of a seam weld when it extends less than full length.

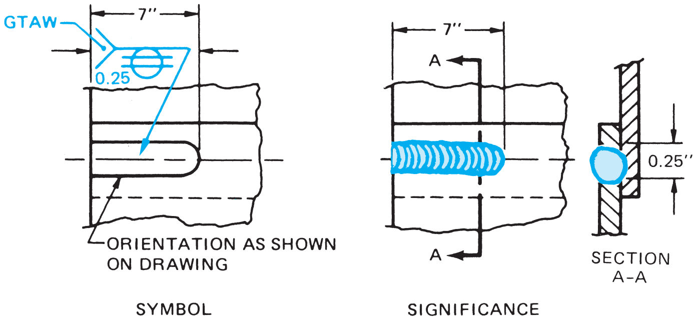


FIGURE 20.7 ■ Application of dimensions for the size and extent of the weld to the seam-weld symbol.

When the center-to-center spacing (pitch) dimension for intermittent seam welds is to be shown, it is placed to the right of the length dimension, Figure 20.8 and Figure 20.9.

A welding symbol specifying the length and pitch of a seam weld without reference to a detail drawing signifies the length and pitch are measured parallel to the axis of the joint to be welded.

When an intermittent seam weld is not made parallel to the joint or axis of the weld, a detailed drawing must be used and reference made to it in the tail of the arrow. For example, the weld shown in Figure 20.10 is to be made at right angles to the joint.

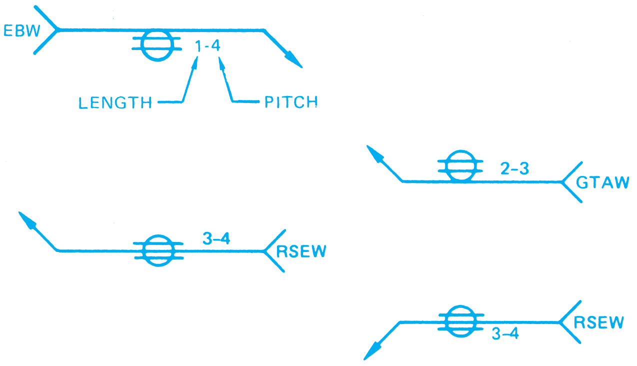


FIGURE 20.8 ■ Application of center-to-center (pitch) dimension.

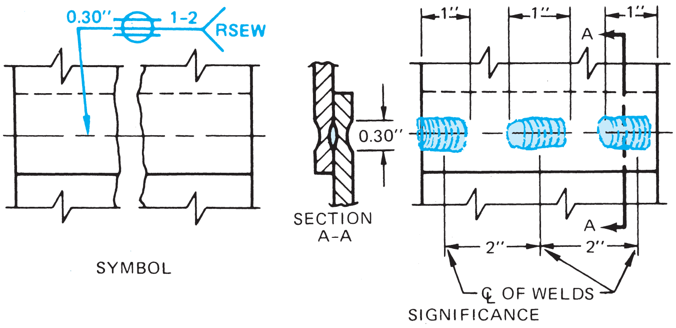


FIGURE 20.9 ■ Application of the size, length, pitch dimensions, and process reference to the seam-weld symbol.

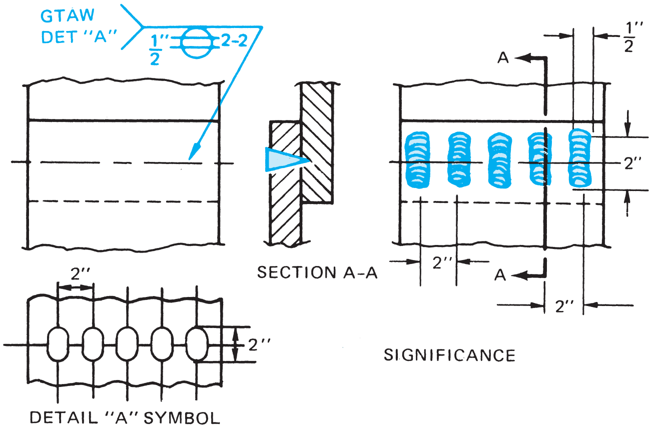


FIGURE 20.10 ■ Method for showing the orientation of a seam weld not parallel to the joint or axis of the weld.

FLUSH-CONTOUR SYMBOL

The flush-contour symbol may be applied to the seam-weld symbol to indicate the member to be made flush. When a flat finish is required, a note is placed in the tail to indicate this. The method for a postweld finish may also be indicated, Figure 20.11. These are not applied to the seam-weld symbol when it is centered astride the reference line as a weld between members is indicated.

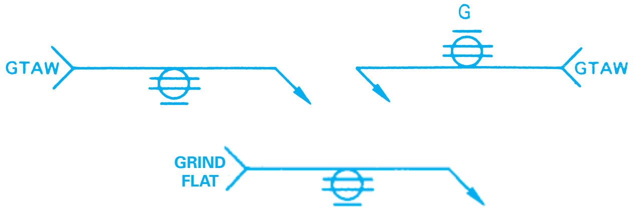


FIGURE 20.11 ■ Flush-contour symbol applied to the seam-weld symbol.

MULTIPLE-JOINT SEAM WELDS

For multiple-joint seam welds, where one or more pieces are inserted between the two outer members, the same symbol and elements are applied to specify the weld as are used for the two-member joints, regardless of the number of pieces inserted, Figure 20.12. In such cases, the symbol has an arrow side or other side significance only.

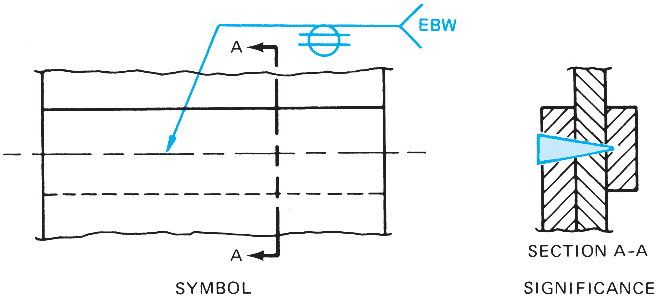


FIGURE 20.12 ■ Multiple-joint seam weld.

UNIT 20: REVIEW

Graph paper is provided at the end of this review for your use.

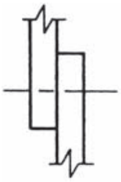
1. List six elements that can be applied to the seam-weld symbol.

2. What element, if any, is added to the seam-weld symbol to differentiate it from the spot weld?

3. Why is a seam-weld symbol used with only a one side significance?

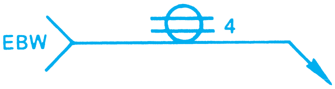
4. a. What is indicated when the seam-weld symbol is located astride the reference line of the welding symbol?

   b. Sketch how the weld should appear.

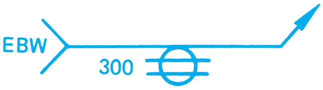


5. What is the meaning of each element shown on the following welding symbols?

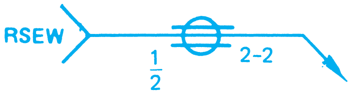
a.



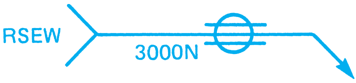
b.



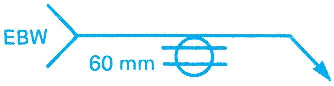
c.



d.

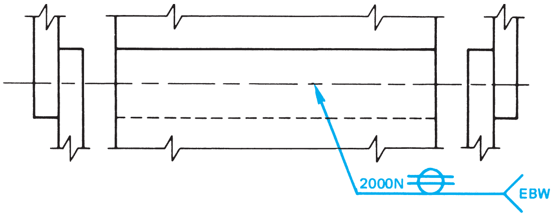


e.

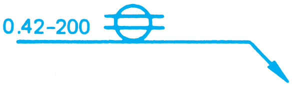


6. a. In the left- or right-side view below, show how the weld should appear as specified in the center sketch.

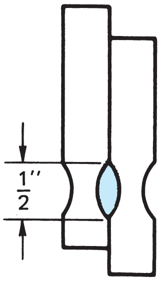
   b. Indicate the significance of the 2000N value.

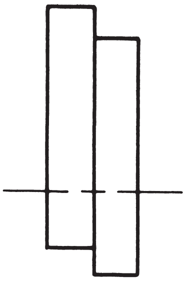


7. Correct the following welding symbol by sketching it correctly.



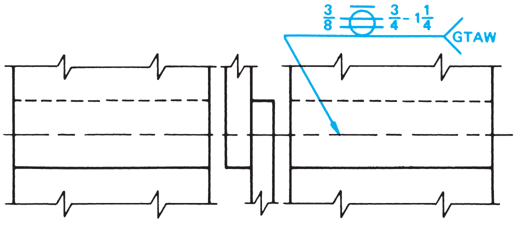
8. How should the welding symbol be shown in the sketch on the right to denote the seam weld shown on the left?





9. When a seam weld is not to be made parallel to the joint, how must this be indicated?

10. Referring to the welding symbol in the right-hand sketch, illustrate the significance of the elements of the welding symbol on the left-hand and center sketches.



11. a. Is the arrow side, other side application of the seam-weld symbol to a multiple-joint seam weld different from its application to a single-joint weld?

____

b. Give a reason for your answer.

____

____

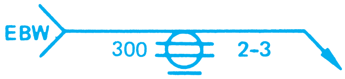
c. Is there any difference in the elements applied to the seam-weld symbol for the multiple-joint seam as compared to the single-joint seam weld?

____

Give a reason for your answer.

____

12. a. What welding process is indicated in the following welding symbol?



____

b. What is the strength specified?

____

c. What is the length and pitch of the seam weld?

Length ______________________________

Pitch ______________________________

13. When a welding symbol refers to a detail drawing, where is this information located on the symbol?

____

____

14. When is a flush-contour symbol not applied to a seam-weld symbol?

____

____

15. Sketch a welding symbol for a seam weld specifying a postweld finish.

UNIT 21

Stud Welds

Stud welding can be described as the joining of a metal stud to another metal workpiece by means of arc, resistance, friction, or other appropriate welding process.

The stud-weld symbol is always shown placed below the reference line, Figure 21.1, with the arrow of the welding symbol pointing to the surface to which the stud is to be welded. An arrow side significance is applied to the symbol. However, it is not used with an other side or both sides significance.

When specifying a stud weld, the arrow of the welding symbol points to the surface to which the stud is to be welded and not to a prepared joint. Therefore, the arrow is not shown with a break when indicating stud welds.

Three elements may be applied to the stud-weld symbol: stud size (diameter), stud spacing (pitch or center-to-center spacing), and the number of stud welds. The stud size dimension is placed to the left of the stud-weld symbol, the number of stud welds is placed in parentheses below the symbol, and the pitch is placed to the right of the symbol, Figure 21.2. The length of the stud is shown on a detailed drawing.

To show the location of studs to be welded in a straight line with equal center-to-center spacing, the spacing (pitch) dimension is applied on the right side of the stud-weld symbol. In addition, the location of the first and last stud is dimensioned on the drawing. A welding process reference stud weld (SW) is included in the tail, Figure 21.3.

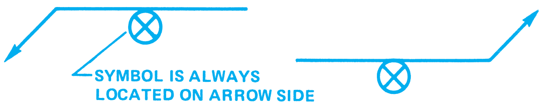


FIGURE 21.1 ■ Shape and location of stud-weld symbol.

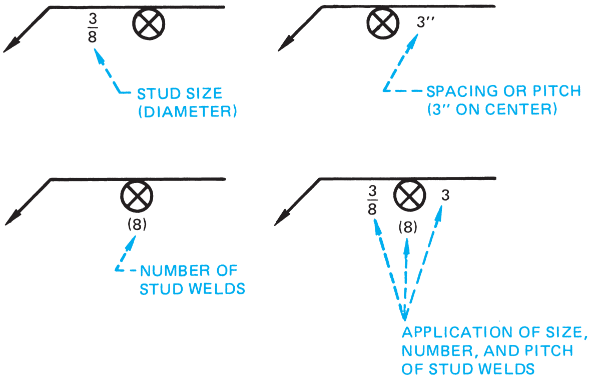


FIGURE 21.2 ■ Application of size, pitch, and number of stud welds to the stud-weld symbol.

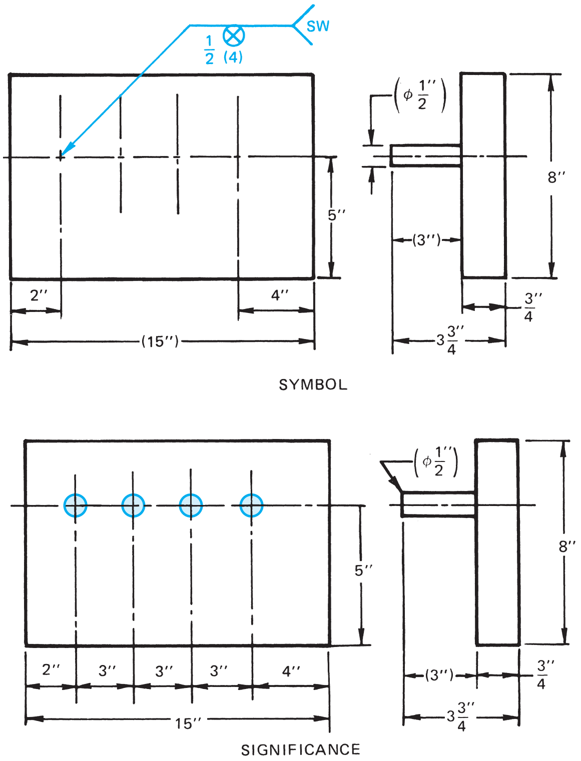


FIGURE 21.3 ■ Dimensioning equally spaced stud welds.

When stud welds are to be made in a straight line with unequal spacing, or in a configuration other than a straight line, the location of each stud must be dimensioned on the drawing, Figure 21.4. Note that multiple arrows may be used in such cases.

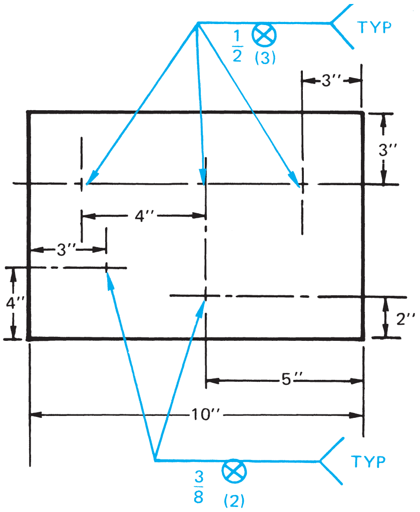
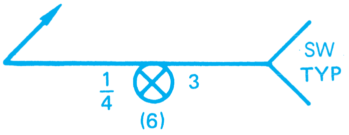


FIGURE 21.4 ■ Dimensioning unequally spaced stud welds.

UNIT 21: REVIEW

Graph paper is provided at the end of each review for your use.

1. Identify the elements applied to the following welding symbol:



¼ ______________________________

⊗ ______________________________

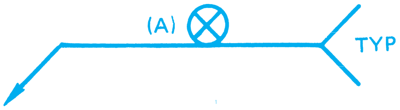
3 ______________________________

(6) ______________________________

SW ______________________________

TYP ______________________________

2. a. Explain what is wrong with the following welding symbol:



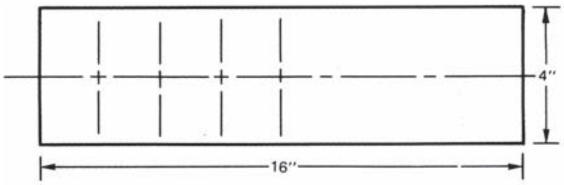
____

____

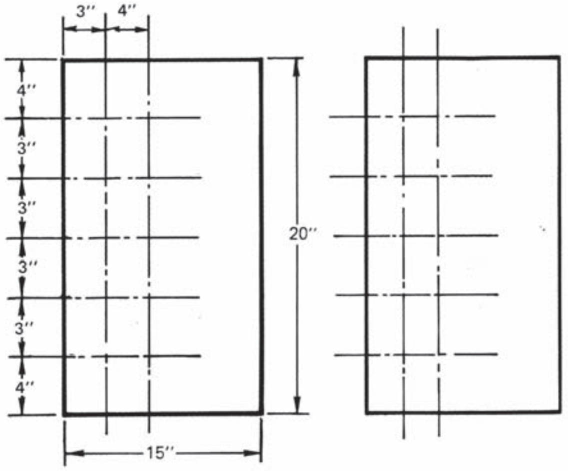
____

b. Sketch the welding symbol in 2(a) so that it is shown correctly.

3. Complete the following sketch by adding a welding symbol to indicate four stud welds centered on the workpiece and in a straight line, 3″ on center with ⅝″ stud size. Include all dimensions necessary for locating the stud welds. Use hypothetical dimensions where necessary.



4. Complete Sketch B by adding a welding symbol to indicate the stud welds required in Sketch A. Include all necessary dimensions. Stud size is ¾″ and the welds are to be typical. The length of the stud is to be 3″.



SKETCH A SKETCH B

SUMMARY REVIEW NO. 3A

1. Sketch the weld symbols for the following:

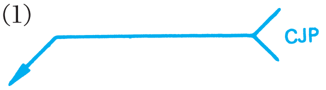
Surface weld	J-groove
V-groove	Spot
Plug weld	Melt-thru
Slot weld	Bevel groove

2. Match the elements in Column B that may be applied to each given type of weld in Column A. (Items in Column B may be used more than once.)

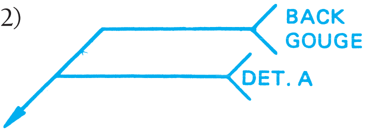
Column A	Column B
Fillet welds	a. size
	b. length
Groove welds	c. strength
	d. included angle
Projection welds	e. pitch
	f. increments
Plug welds	g. side of joint
	h. extent of welding
Slot welds	i. contour
	j. method of finish
	k. field weld

3. Sketch the appropriate symbol for each of the following:
   a. field weld
   b. weld-all-around
   c. convex contour
4. List the finish abbreviations used with contour symbols and give the meaning of each.
5. a. What type of information is usually placed in the tail of a welding symbol?
   b. Describe the significance of the references included in each of the welding symbols shown.

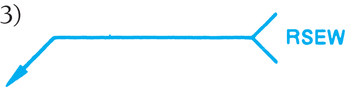
(1)



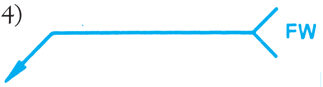
(2)



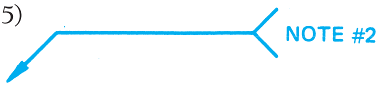
(3)



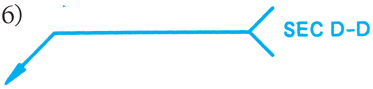
(4)



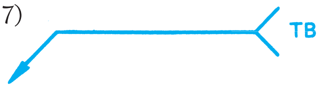
(5)



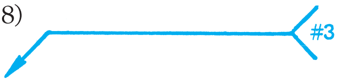
(6)



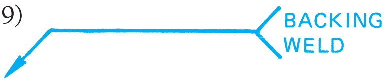
(7)



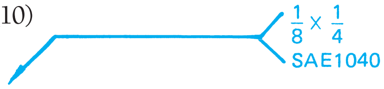
(8)



(9)



(10)



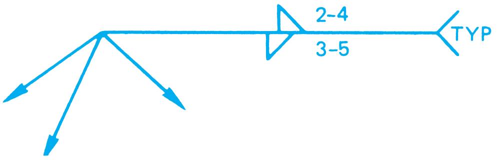
6. When is it necessary to use a break in the arrow line of the welding symbol?

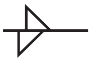
____

7. Draw the symbol for a ½″ fillet weld on the arrow side made flat by chipping, and a ¾″ fillet weld on the other side ground to a convex contour.

8. With a sketch, show how a welding symbol is applied to indicate a slot weld.

9. a. Describe the elements contained in the following welding symbol.



 ______________________________________

2-4 ______________________________________

3-5 ______________________________________

TYP ______________________________________

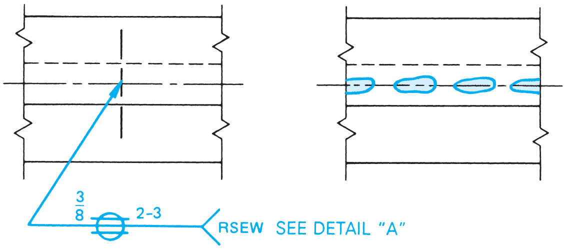
b. Explain why multiple arrows are sometimes applied to a welding symbol.

____

____

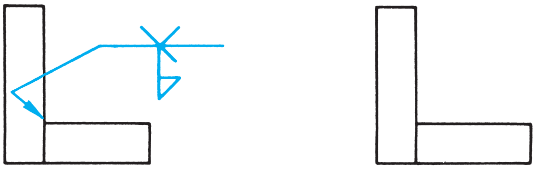
____

10. Apply the dimensions to Sketch "B" indicated by the welding symbol shown in Sketch "A."



SKETCH "A" SKETCH "B"

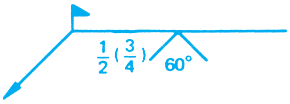
11. Complete Sketch "B" to show the significance of Sketch "A."



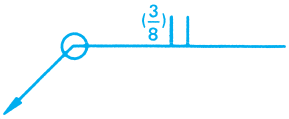
SKETCH "A" SKETCH "B"

12. Interpret the significance of each item of information on the following welding symbols.

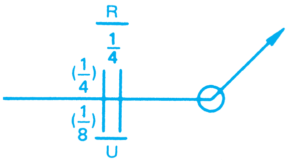
a.



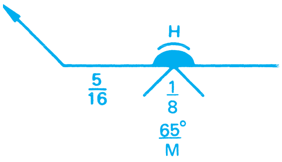
b.



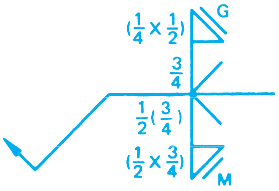
c.



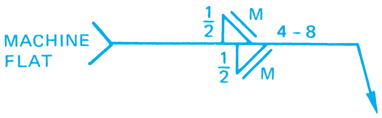
d.



e.



f.



a. ______________________________________

____

b. ______________________________________

____

c. ______________________________________

____

d. ______________________________

____

e. ______________________________

____

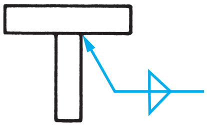
f. ______________________________

____

13. a. Identify the joints shown in the following sketches.

b. Identify by name each of the weld symbols indicated.

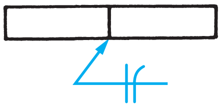
(1)



(a) ____________________

(b) ____________________

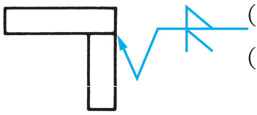
(2)



(a) ____________________

(b) ____________________

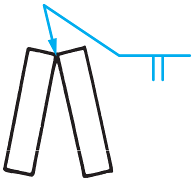
(3)



(a) ____________________

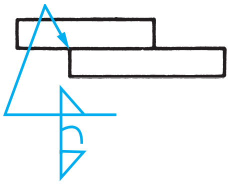
(b) ____________________

(4)



(a) ____________________

(5)



(a) ____________________

(b) ____________________

14. How is a thermit weld indicated on the welding symbol?

____

____

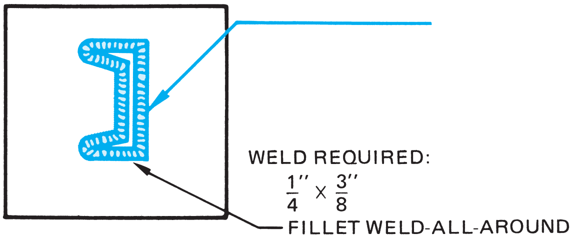
15. Describe the difference between a weld symbol and a welding symbol.

____

____

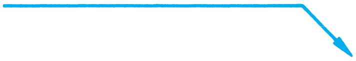
____

16. Complete the following welding symbol to indicate the weld required.

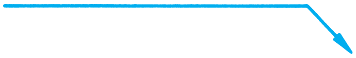


17. Complete the following welding symbols by adding the weld symbols indicated.

a. An arrow side fillet weld made in the field.

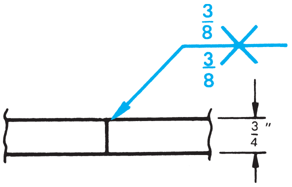


b. An other side fillet weld-all-around made in the field.

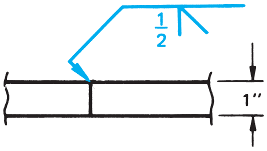


18. Show the preparation of the joints by using dotted lines and the welds formed by using solid lines for the following symbols:

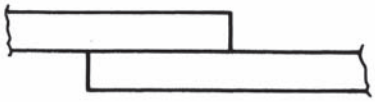
a.



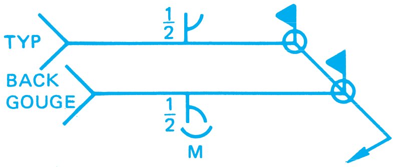
b.



19. Apply a welding symbol to the following sketch using a double reference line to indicate square groove welds on both sides, followed by fillet welds on both sides.



20. a. Which weld is the first weld to be made as indicated by the following welding symbol?



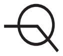
____

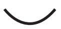
b. Describe each of the elements shown.

TYP ____________________

____

____


____

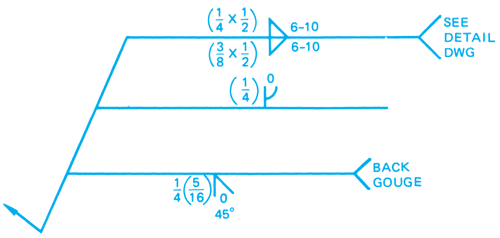

____

M ____________________

BACK GOUGE ____________________

c. Prepare a sketch that illustrates the welds required by the welding symbol in 20(a) with application to a T-joint. Include the welding symbol shown in 20(a).

21. a. Identify the sequence of welds specified in the following welding symbol:



(1)____________________

(2)____________________

(3)____________________

b. When is the back gouging to be performed?

____

c. Describe the dimensions applied to each of the weld symbols shown in 21(a).

$\frac{1}{4}(\frac{5}{16})$ ____________________

0 ____________________

45° ____________________

$(\frac{1}{4})$ ____________________

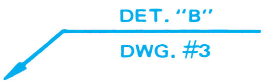
0 ____________________

$(\frac{1}{4} \times \frac{1}{2})$ ____________________

6-10 ____________________

$(\frac{3}{8} \times \frac{1}{2})$ ____________________

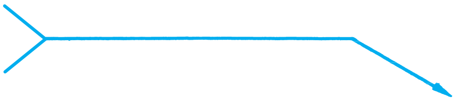
22. Explain the significance of the elements shown in the following welding symbol.



____

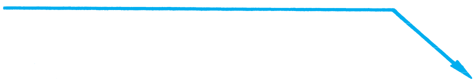
____

23. Complete the welding symbol for the following: a single V-groove on the other side, grooved to a depth of ½″, ¼″ groove weld size with $\frac{3}{16}$″ root gap or spacing and a groove angle of 65°. Weld is to be a flat contour with an indication that the method of finish is unspecified.

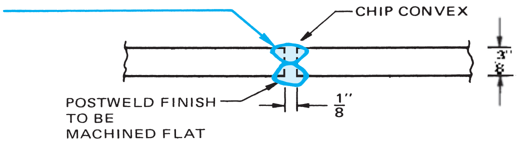


24. Sketch the weld symbol used to indicate a weldment with a backing. Include an indication that the backing material is to be removed.

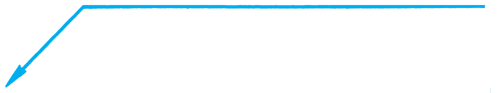
25. Complete the welding symbol to indicate the following: a single V-groove weld on the arrow side, grooved to a depth of ⅝″ with ⅛″ root opening and 65° included angle. Weld to be chipped flat-faced on arrow side. On the other side there is to be a back weld, which is to be ground to a convex contour.



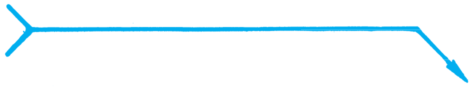
26. Complete the welding symbol to indicate the following welds:



27. Complete the welding symbol to indicate spot welds of 600 pounds shear strength per spot to be spaced on 2″ centers. Weld is to be on arrow side.



28. Complete the welding symbol to indicate six spot welds with a shear strength of 2000 Newtons per spot, pitch of 50 millimeters, welds to be on the other side, and process to be electron-beam welding.



29. Where is the depth of filling placed on the slot welding symbol?

____

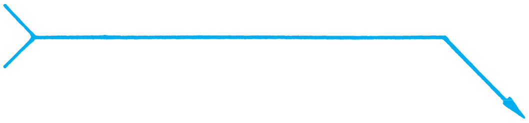
____

30. How does a slot weld differ from a plug weld?

____

____

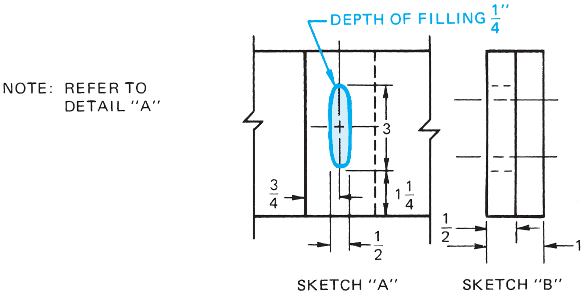
31. Complete the welding symbol to indicate intermittent seam welds with a shear strength of 3000 pounds per inch. Welds to be 2″ long on 5″ centers, and are to be welded flush on arrow side. Welding process to be gas tungsten arc welding.



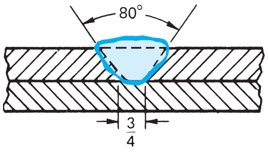
32. Complete the following symbol to indicate a 3⁄16″ thick surfacing weld on arrow side machined flat.

33. a. Sketch the symbol required to indicate the following slot weld. Include reference to Detail "A."

b. Show how the weld would appear using Sketch "B" for this purpose.

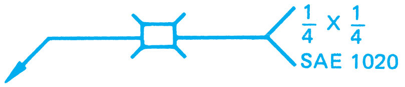


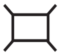
34. Sketch the welding symbol that indicates the following weld.



3/4 DIAMETER PLUG WELD WITH FLAT CONTOUR, MACHINE FINISH, 8″ PITCH BETWEEN WELDS, MATERIAL ACCORDING TO SPECIFICATION "C"

35. Give the significance of each of the elements shown in the following welding symbol. Prepare a sketch that shows the welds required for the symbol given.



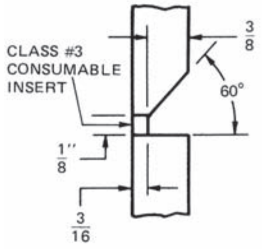
 ______________________________

1/4 × 1/4 ______________________________

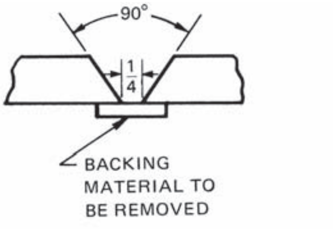
SAE 1020 ______________________________

36. Sketch the welding symbol that will indicate the joint preparation and other elements required for the following illustrations.

a.

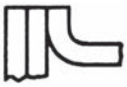


b.

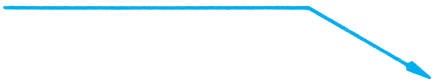


NOTE: SIZE OF BACKING IS 1″/8 X 1″/2

37. Apply a welding symbol to the following sketch to specify an edge weld with a ¼″ thickness.

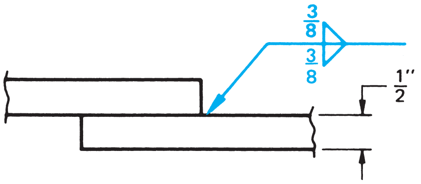


38. Complete the welding symbol below to illustrate a ¾″ plug weld on the arrow side with angle of countersink 30° and 6″ spacing. Weld is to have a flat machine finish.

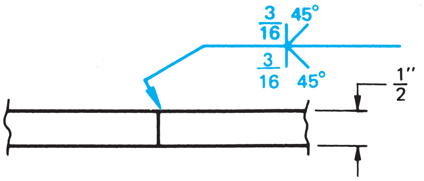


39. Draw the weld and show all dimensions given on the following symbols:

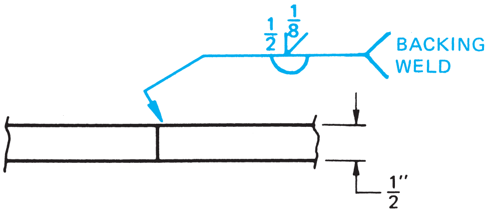
a.



b.

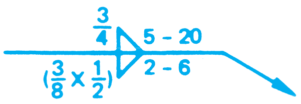


c.

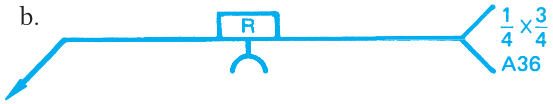


40. List the information given on the following symbols:

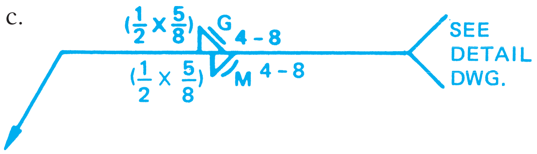
a.



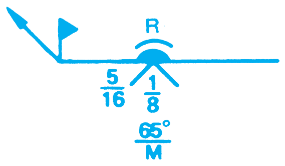
b.



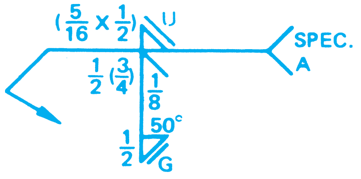
c.



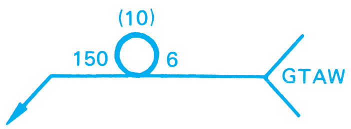
d.



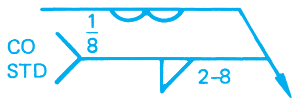
e.



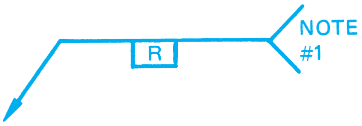
f.



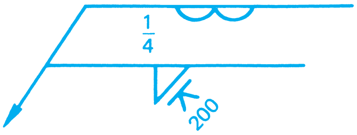
g.



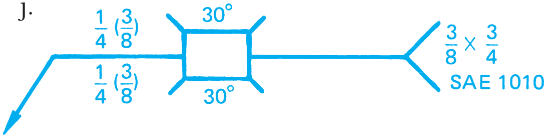
h.



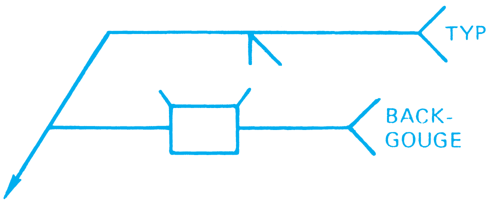
i.



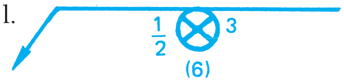
j.



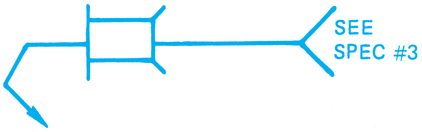
k.



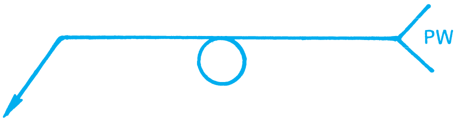
l.



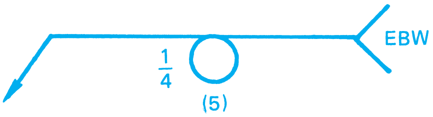
m.



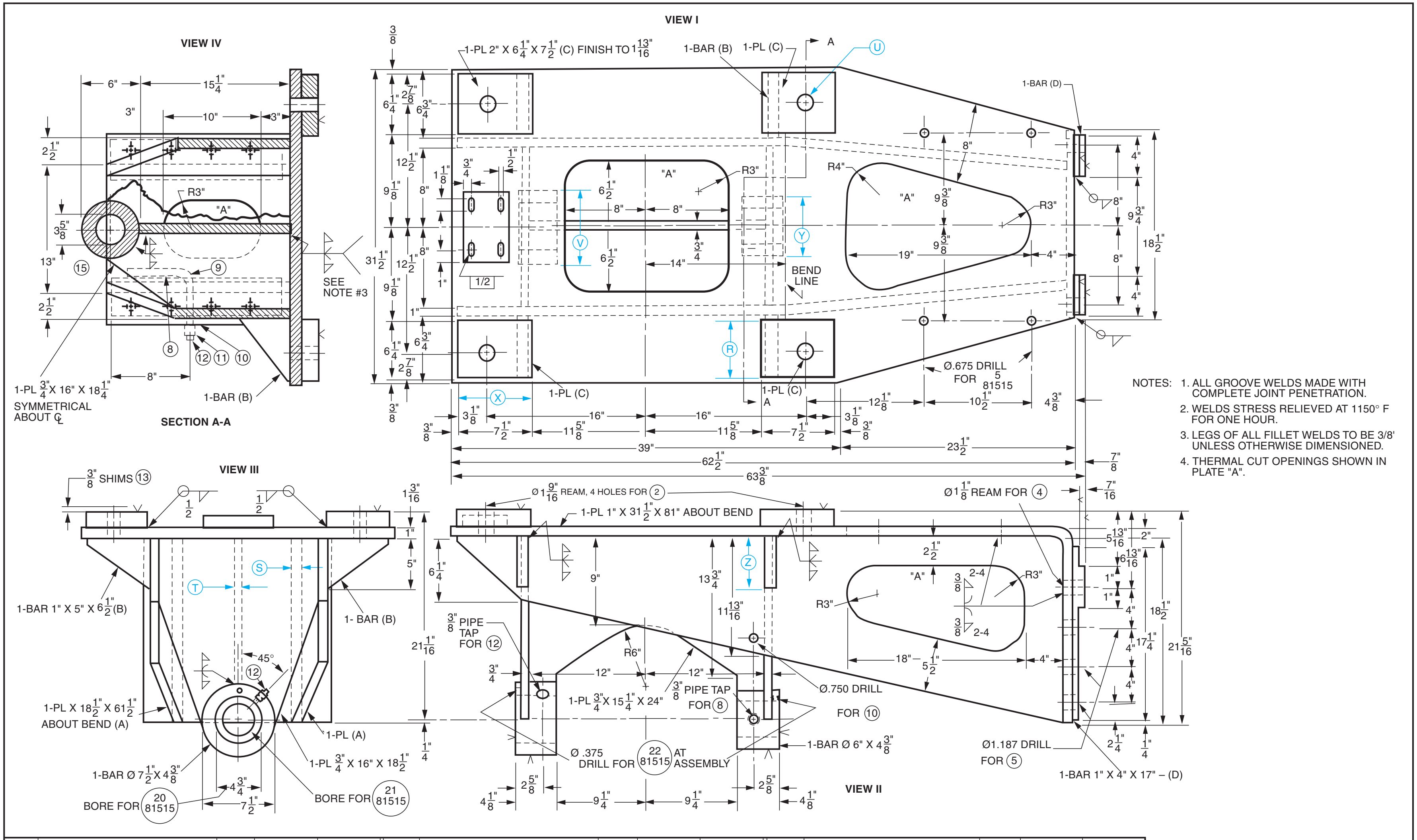
n.



o.



41. Sketch three joints to which the edge weld symbol may be applied. Identify those joints that primarily have application to sheet metal joinery.



NOTES:
1. ALL GROOVE WELDS MADE WITH COMPLETE JOINT PENETRATION.
2. WELDS STRESS RELIEVED AT 1150° F FOR ONE HOUR.
3. LEGS OF ALL FILLET WELDS TO BE 3/8" UNLESS OTHERWISE DIMENSIONED.
4. THERMAL CUT OPENINGS SHOWN IN PLATE "A".

NO.	PARTS REQUIRED	IT.	PAT NO.	MAT'L.	NO.	PARTS REQUIRED	IT.	PAT NO.	MAT'L.	NO.	PARTS REQUIRED	IT.	PAT. NO.	MAT'L.
8	MOTOR SUPPORT FRAME	1	WELD CONSTR.	ANN. ST'L.	8	3/8" X 90° ELBOW	9		PIPE	1	6" DIA X 4 3/8"	16		A. ST'L.
					8	3/8" PIPE X 4 LG	10		"	1	7 1/2" DIA X 4 3/8"	17		"
32	1 9/16" X 7 1/4" HEX NUT	2	F525A	"	8	3/8" PIPE COUPLYING	11		"	2	BAR 1" X 4" X 5 1/4"	18		"
32	1 1/2" CP HEX NUT	3	FOR ②	"	16	3/8" ALEM. 1714 FITTING	12			4	BAR 1" X 5" X 6 1/2"	19		"
16	1 1/2" X 4 1/2" FIN BOLT	4	F525	"	32	SETS OF SHIMS EACH SET CONSISTING 2–1/16"THICK 2–1/32" THICK	13		ST'L.	4	BAR 2" X 6 1/4" X 7 1/2"	20		"
48	1 1/8" X 3 5/8" SQ HD BOLT	5		"						1	PL 3/4" X 15 1/4" X 24	21		"
64	1 1/8" LOCK WASHER	6	FOR ④⑤	"						2	PL 3/4" X 16 X 18 1/4"	22		"
64	1 1/8" CP HEX NUT	7	" " "	"	32	1 1/2" CP HEX CHECK NUT	14	FOR ②	ST'L.	2	PL 1" X 18 1/2" X 61 1/2"	23		"
8	3/8" PIPE X 6 7/8" LG	8		PIPE	8	3/8" X 90° STREET ELBOW	15		PIPE	1	PL 1" X 31-1/2" X 6'–9"	24		"

DRAWN BY: L.J. SIY
SCALE: 1/8" = 1"

TWO TROLLEYS FOR 20 TON
ORE BRIDGE TROLLEY DRIVE
MOTOR SUPPORT FRAME

EDITOR'S NOTE: REDUCED PRINT. FOLLOW STATED DIMENSIONS ONLY. NOT TO BE SCALED.

A LARGER DRAWING IS PROVIDED AT THE BACK OF THE TEXT.

SUMMARY REVIEW NO. 3B

The questions that follow refer to the Motor Support Frame drawing, page 249.

1. Name the views that are used to show the part.

2. a. List the types of lines used on the print.

   b. What type of line is used to show the bend line?

   c. Identify the methods for making circular holes in the part.

3. How are openings designated by the letter “A” to be made?

4. a. What size hole is specified for the 1⅛″ square head bolt?

   b. What tolerances are specified for holes?

5. Give the dimensions for distances:

Ⓡ ____________ Ⓥ ____________
Ⓢ ____________ Ⓧ ____________
Ⓣ ____________ Ⓨ ____________
Ⓤ ____________ Ⓩ ____________

6. List the overall dimensions of the part.

7. A ⅜″ thickness of shims is specified for one of the parts. Give the number and sizes of shims to be used to make up this thickness.

8. What types of structural metal shapes are needed to fabricate the part?

9. Sketch the symbol used on the print to signify a pipe thread.

10. How many surfaces are to be finished?

11. What method of dimensioning is used?

12. a. List a general note found on the print that refers to the size of the fillet weld.

    b. Show the significance of this specification by means of a sketch.

13. Sketch the different welding symbols found on the drawing. Explain the significance of each. Use graph paper provided for answers.

14. What is the groove weld size of all groove welds?

15. Why are joints welded on both sides?

16. Sketch those symbols found on the print that indicate that joint preparation is required. Identify each.

17. Identify the views shown on the drawing.

18. How many 2″ × 6¼″ × 7½″ plate pieces are required?

19. Identify Item 12 as listed on the print.

____

20. List two dimensions found in the section drawing considered to be reference dimensions.

____

____

21. a. Sketch the symbol for a finished surface.

    b. How many surfaces are to be finished?

____

22 UNIT

Applied Metrics for Welders

INTRODUCTION TO METRICS

The primary system of measurement used by most of the world is the metric system. The word "metric" is derived from the Greek word "metron," meaning measure. This system is often identified by the initials SI, which is the abbreviation for Systems Internationale.

STRUCTURE OF THE METRIC SYSTEM

Base Units

The metric system consists of three classes of SI units: (1) base units, which are units of measure; (2) supplementary units, which apply to the measurement of angles; and (3) derived units, which are adaptations of base and supplementary units.

There are seven SI base units of measure: (1) the **meter** (or metre) for length; (2) the **kilogram** for mass (or weight); (3) the **second** for time; (4) the **ampere** for electric current; (5) the **candela** for intensity of light; (6) the **mole** for amount of substance; and (7) *Kelvin* (or Celsius) for temperature. Although the Kelvin is listed as the base unit for temperature, the degree Celsius is generally used in place of Kelvin. Celsius (abbreviated C) has replaced the previously used term centigrade. On the Celsius temperature scale, 0° represents the freezing point of water and 100° represents the boiling point of water.

Table 22.1 illustrates the seven SI basic units of measure and the symbols used to represent them.

Quantity Represented	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	Kelvin (or Celsius)	K (°C)
Amount of substance	mole	mol
Luminous intensity	candela	cd

TABLE 22.1 ■ SI base units.

Supplementary Units

There are two supplementary units, the radian and the steradian, as indicated in Table 22.2.

The **radian** is the unit used to represent a plane angle, which is equal to 57.3°, Figure 22.1. Since one radian represents a relatively large angle of measure, it is not often used on a drawing, except in cases when it is essential that SI units be maintained

Quantity Represented	Name	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

TABLE 22.2 ■ SI supplementary units.

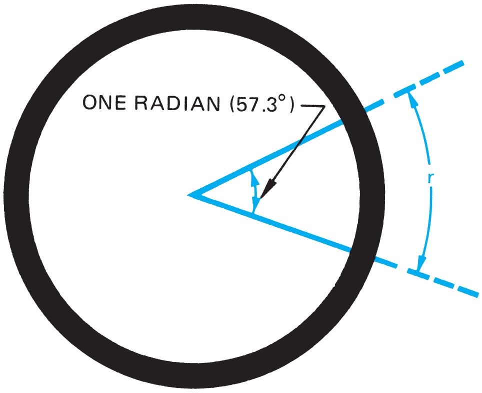


FIGURE 22.1 ■ The radian.

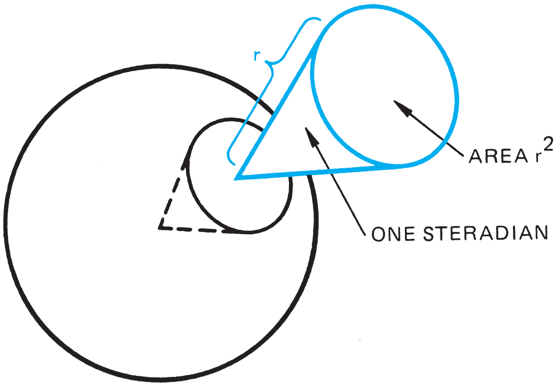


FIGURE 22.2 ■ The steradian.

throughout the drawing. In such cases, values of less than 57.3° are shown as decimal fractions of a radian. For example, 11° 30′ would be shown as 0.20 radian (11° 30′ ÷ 57.3° = 0.20 rad). Note that one degree approximates 0.017 radian. This value can be used as a constant for converting a degree value to a radian value and, conversely, to change a radian value to a degree value.

Examples: To change 5° to a radian value, multiply 5° × 0.017 = 0.085 radian.

To change 0.35 radian to degrees, divide 0.35 by 0.017 = 20.6°.

Although not a part of SI, the degree (°), minute (′), and second (″) symbols are generally used on drawings to represent plane angle dimensions. When an angular measurement includes minutes and seconds, it is preferred practice to show the minutes and seconds as a decimal fraction of a degree. For example, on a metric drawing, 30° 14′35″ is best shown as 30.25° or 30.3°.

The **steradian** is the SI unit of measure for a solid angle. Such an angle has its vertex in the center of a sphere and cuts off an area of the surface of the sphere equal to the area of a square having sides the same length as the radius of the sphere, Figure 22.2.

Solid angle dimensions are not generally shown on two dimensional drawings. Reference is rarely made to steradian as a dimensional value. This unit is more likely to be used in technical data dealing with lighting.

Derived Units

Derived units are SI quantities obtained by combining base and supplementary units. The formation of a derived unit may involve multiplying or dividing a unit by itself, by another base unit, or by a supplementary unit; or it may be accomplished by directly combining units into a single expression.

Derived units are developed as needed. The following examples show how these units are derived. In the examples shown, a diagonal line (/) is used to mean the mathematical process of division (÷), and a raised dot (·) is used to indicate multiplication (×).

1. Multiplying m·m (meter squared) produces the derived unit for "area." The derived unit symbol is m^2.
2. Multiplying m·m·m (meter cubed) produces the derived unit for "volume." The derived unit symbol is m^3.
3. Dividing watts by amperes (W/A) produces the derived unit volt for "electromotive force." The derived unit symbol is V.

The list of derived units is extensive, having application to electricity, lighting, mechanics, and welding. Derived units concerned with welding are illustrated in Table 22.3 (as identified by the American Welding Society).

Quantity Represented	Name	Symbol
Area dimensions	square millimeter	mm^2
Current density	ampere per square millimeter	A/mm^2
Deposition rate	kilogram per hour	kg/h
Electrical resistivity	ohm meter	Ω·m
Electrode force (upset, squeeze, hold)	Newton	N
Flow rate (gas and liquid)	liter per minute	L/min
Fracture toughness	megaNewton meter	$MN{\cdot}m^{-3/2}$
Impact strength	joule	J=N·m
Linear dimensions	millimeter	mm
Power density	watt per square meter	W/m^2
Pressure (gas and liguid)	Pascal	$Pa=N/m^2$
Tensile strength	Pascal	$Pa=N/m^2$
Thermal conductivity	watt per meter Kelvin	W/(m·k)
Travel speed	millimeter per second	mm/s
Volume dimensions	millimeter cubed	mm^3
Wire feed rate	millimeter per second	mm/s

TABLE 22.3 ■ Derived units pertaining to welding.

METRIC PREFIXES

In order to specify different values of metric base units of measure a set of prefixes is used, Table 22.4. When a prefix is applied to a base unit, it increases or decreases its value. A prefix that increases the value of a base unit is termed a multiple, and one that decreases its value is termed a submultiple.

The kilogram, for mass (weight), is the only base unit that initially contains a prefix; however, double prefixes are not applied to base units. In this case, it is standard practice to apply a prefix to the gram and not to the kilogram.

Prefixes represent powers of 10 and are comparable to the decimal numeration system illustrated in Table 22.4.

Decimal Numeration	Metrix Prefix	
thousandths—1/1000	milli	Decrease
hundredths—1/100	centi	
tenths—1/10	deci	
ones—1	base unit	
tens—10	deka	Increase
hundreds—100	hecto	
thousands—1000	kilo	

TABLE 22.4 ■ Comparison of decimal numeration to prefixes.

ISO INCH AND ISO METRIC SCREW THREADS

Screw thread designations on metric drawings are preferably shown in either ISO unified inch or ISO metric sizes. ISO is the abbreviation for International Organization for Standardization, which is concerned with establishing standards for industry worldwide. (See Unit 26 for more information.)

ISO has recommended certain of the American screw thread sizes for use with SI. These include a selected assortment of National Coarse (NC), National Fine (NF), and National Extra Fine (NEF) thread sizes. They are identified by the addition of the capital letter "U" (meaning unified) to each of the abbreviated thread classifications:

UNC for Unified National Coarse
UNF for Unified National Fine, and
UNEF for Unified National Extra Fine.

It should be noted that certain American screw thread sizes not classified as unified (for example, –13NC) will also be found on prints during the transition period to metrics.

The elements applied for designating an ISO inch (unified) thread size on a metric drawing are illustrated in Figure 22.3.

Metric threads have the same basic form as the American National Thread. That is, each thread form has an included angle of 60°, Figure 22.4. The principal difference in the forms is that a metric thread has a greater depth in the cut of the thread. The manner in which an ISO metric size is designated on a metric drawing is illustrated in Figure 22.5.

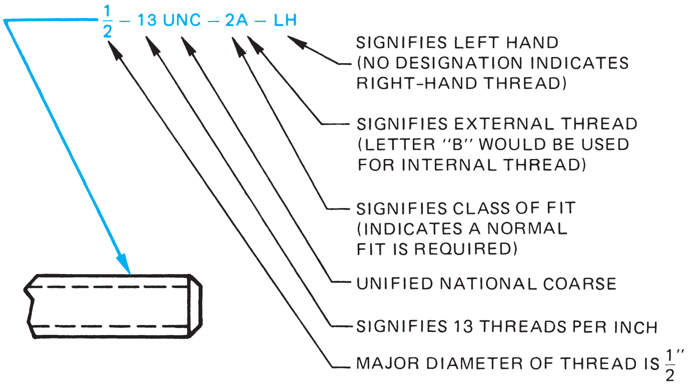

$\frac{1}{2}$ – 13 UNC – 2A – LH
SIGNIFIES LEFT HAND (NO DESIGNATION INDICATES RIGHT-HAND THREAD)
SIGNIFIES EXTERNAL THREAD (LETTER "B" WOULD BE USED FOR INTERNAL THREAD)
SIGNIFIES CLASS OF FIT (INDICATES A NORMAL FIT IS REQUIRED)
UNIFIED NATIONAL COARSE
SIGNIFIES 13 THREADS PER INCH
MAJOR DIAMETER OF THREAD IS $\frac{1}{2}''$

FIGURE 22.3 ■ ISO inch (unified) thread designation.

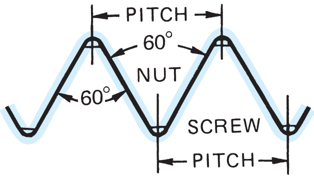


FIGURE 22.4 ■ Thread form of ISO inch and ISO metric threads.

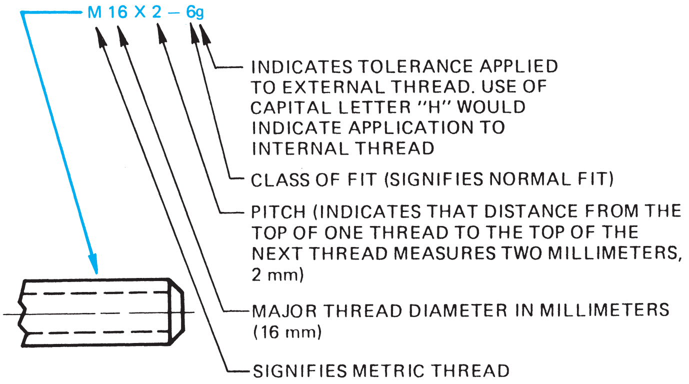

M 16 X 2 – 6g
INDICATES TOLERANCE APPLIED TO EXTERNAL THREAD. USE OF CAPITAL LETTER "H" WOULD INDICATE APPLICATION TO INTERNAL THREAD
CLASS OF FIT (SIGNIFIES NORMAL FIT)
PITCH (INDICATES THAT DISTANCE FROM THE TOP OF ONE THREAD TO THE TOP OF THE NEXT THREAD MEASURES TWO MILLIMETERS, 2 mm)
MAJOR THREAD DIAMETER IN MILLIMETERS (16 mm)
SIGNIFIES METRIC THREAD

FIGURE 22.5 ■ ISO metric thread designation.

PIPE THREAD DESIGNATIONS ON METRIC DRAWINGS

Dimensioning data for American Standard Pipe Threads is applied in the same form to both metric and nonmetric drawings. There are two types of designations for this thread: National Pipe Taper (NPT) and National Pipe Straight (NPS). The NPT thread is a tapered thread with a taper of 0.75″ per foot. The NPS thread is a straight thread. Each type has application for particular types of joint requirements. The included angle of a pipe thread form is 60°. The manner in which National Pipe Threads are designated is illustrated in Figure 22.6. It should be noted that National Pipe Threads derive their sizes from the nominal sizes of the pipe to which the threads are applied.

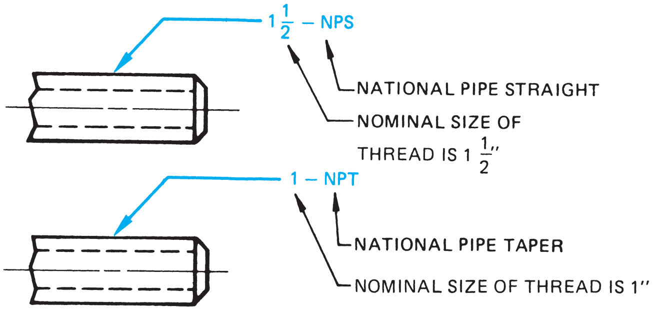

$1\frac{1}{2}$ – NPS
NATIONAL PIPE STRAIGHT
NOMINAL SIZE OF THREAD IS $1\frac{1}{2}$″
1 – NPT
NATIONAL PIPE TAPER
NOMINAL SIZE OF THREAD IS 1″

FIGURE 22.6 ■ Pipe thread designation.

A list of coarse and fine metric thread sizes is shown in Table 22.5. Note that for coarse threads (also sometimes identified as standard metric threads), prefix M and the diameter (in millimeters) is used for specifying the thread. For fine threads, the prefix M, diameter (in millimeters), and the pitch (in millimeters) must be used. The pitch represents the distance from the crest of one thread to the crest of the next thread.

Nominal Size	Pitch	Coarse Thread	Fine Thread
4	0.7	M4	M4 x 0.5
5	0.8	M5	M5 x 0.5
6	1	M6	M6 x 0.75
7	1	M7	M7 x 0.75
8	1.25	M8	M8 x 1
9	1.25	M9	M9 x 1
10	1.5	M10	M10 x 1.25
12	1.75	M12	M12 x 1.25
16	2	M16	M16 x 1.5
20	2.5	M20	M20 x 1.5
24	3	M24	M24 x 2

TABLE 22.5 ■ Listing of coarse and fine metric thread sizes.

MATERIALS IN METRIC SIZES

Many components shown on metric prints can be fabricated from materials that are available in standard metric sizes. However, when materials in metric sizes are not available, materials in inch sizes that most closely match the metric sizes are used. In certain cases, it may be necessary to machine the material to the metric size required. This is true particularly when there is a significant difference between the inch size material that is available and the metric sizes that are specified for a fabrication.

As more materials become available in standard metric sizes, the problem of conversion will be reduced. In the meantime, the welder should be able to convert metric to inch and inch to metric dimensions to select material sizes that will be most economical in the fabrication of a weldment.

The most common metric value found on a print is the millimeter. Tables of inch–millimeter conversions are contained in Appendix 1. Mathematical constants that may be used for making conversions, in the event conversion tables are not available, are shown in Table 22.6.

Note that when converting an inch value to a millimeter value a multiplication process is used. The same constants may be used to convert a metric value to an inch value. In this case, the inch value is divided by the appropriate constant. Examples of these processes follow (the underlined figures are the constants):

Inch(es) to millimeter(s)

$16'' \times \underline{25.4} = 406.4$ mm

Linear Conversion		
From	**To**	**Multiply by**
inches	millimeters	25.4
feet	meters	0.305
yards	meters	0.914
Area Conversion		
square inches	square millimeters	645.2
square feet	square meters	0.093
square yards	square meters	0.836
Volume Conversion		
cubic inches	cubic millimeters	1.639
cubic feet	cubic meters	0.028

TABLE 22.6 ■ Constants for metric conversions.

Square feet to square meter(s)
20 square feet × 0.093 = 1.86 m^2 (square meters)

Cubic inch(es) to cubic millimeter(s)
20 cubic inches × 1.639 = 19.668 mm^3 (cubic meters)

Millimeter(s) to inch(es)
173 mm ÷ 25.4 = 6.811 inches

Square meter(s) to square feet
14 m^2 ÷ 0.093 = 150.537 square feet

Cubic meter(s) to cubic feet
20 m^3 ÷ 0.028 = 714.285 cubic feet

STANDARD PRACTICES FOR PRESENTING METRIC EXPRESSIONS AND DIMENSIONS ON METRIC DRAWINGS FOR WELDMENTS

- When a millimeter dimension is less than 1, a "0" is shown preceding the decimal point. Note that the abbreviation "mm" is not used when applying a metric dimension to a welding symbol; rather it is so indicated by a general note on the print.

Example:

Correct	*Incorrect*
0.08 mm	.08 mm

- A decimal point and a zero are not shown when the millimeter dimension is a whole number.

Example:

Correct	*Incorrect*
8 mm	8.0 mm

- A millimeter dimension with a whole number and a decimal fraction is not shown with a 0 following the decimal fraction. However, this practice does not apply to tolerance dimensioning.

Example:

Correct	*Incorrect*
2.2 mm	2.20 mm

- A metric dimension is given as a decimal fraction rather than a common fraction.

Example:

Preferred	*Obsolete*
0.625 mm	$\frac{5}{8}$ mm

- An “s” is not added to a symbol to make it plural. The symbol without an “s” represents both singular and plural units.

Example:

Correct	*Incorrect*
16 mm	16 mms

- Symbols for metric units are shown in lowercase letters, except for units derived from the names of people.

Example:

Correct	*Incorrect*
6 mm	6 Mm

- Metric tolerances are shown on a drawing with the positive tolerance placed above the minus tolerance. A zero tolerance is indicated by a 0, whether it be plus or minus.

Examples:

Correct	*Incorrect*
$\leftarrow 3.25^{+0.05}_{-0} \rightarrow$	$\leftarrow 3.25^{-0}_{+0.05} \rightarrow$
$\leftarrow 3.25^{+0}_{-0.05} \rightarrow$	$\leftarrow 3.25^{-0.05}_{+0} \rightarrow$

- Drawings dimensioned in millimeters will not show the digits separated into groups by commas or spaces.

Examples:

Correct	*Incorrect*
1650	1,650
12570	12 570

- When all dimensions on a drawing are shown in millimeters, an identification of each dimension by the abbreviation “mm” is not required. The same applies when all dimensions are in inches. That is, the “IN” abbreviation is not used following each dimension. However, when some inch dimensions are included on a millimeter-dimensioned drawing, the abbreviation “IN” is used after each inch value. Also, when some millimeter dimensions are applied to an inch-dimensioned drawing, the abbreviation “mm” is applied following each millimeter value. Notes, as shown below, are applied to the drawing to clarify the application of millimeter and inch values.

  Note: Unless otherwise specified, all dimensions are in millimeters.

  Note: Unless otherwise specified, all dimensions are in inches.

- A semicolon is used rather than a comma to separate metric dimensions that are shown in sequence.

Example:

Correct	28 mm; 16 mm; 5 mm
Incorrect	28 m, 16 mm, 5 mm

- When a note or specification indicates that SI units are to be multiplied, a raised dot (·) is included between symbols in place of a times (×) sign. However, a raised dot *is not used between numbers* because it may be misinterpreted as a decimal point. A times sign (×) is used to indicate multiplication of numbers.

Example:

Correct	*Incorrect*
C = A·S	C = A × S
17 × 25	17·25

- Metric prefixes shown on a drawing or in specifications will generally remain the same throughout. They are not mixed in one expression. In most cases the prefix "milli" is used. Variations in its value are accomplished by changing the location of the decimal point in the numbers being expressed.

Examples:

Correct	*Incorrect*
6 *mm* long	6 *mm* long
× 20 *mm* high	× 0.02 *m* high

- When converting an inch dimension not having a tolerance to a millimeter equivalent, the conversion is made to the same preciseness or better. For more examples, see Table 22.7.

Example:

Correct	16.50" = 419.10 mm
Incorrect	16.50" = 419 mm

Electrode Sizes		Fillet Sizes	
in.	mm	in.	mm
0.030	0.76	1/8	3
0.035	0.89	5/32	4
0.040	1.02	3/16	5
0.045	1.14	1/4	6
1/16	1.59	5/16	8
5/64	1.98	3/8	10
3/32	2.38	7/16	11
1/8	3.18	1/2	13
5/32	3.97	5/8	16
3/16	4.76	3/4	19
1/4	6.35	7/8	22
		1	25

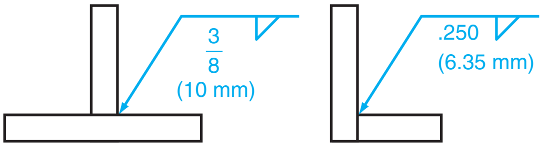
U.S. Customary (inch)

Metric (millimeters)

TABLE 22.7 ■ Conversion tables.

- Dual dimensioning including U.S. Customary units (common and/or decimal fractions) and millimeter units may also be found on prints; however, it is not standard practice.

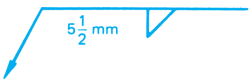
Example:

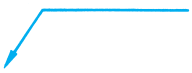


UNIT 22: REVIEW A

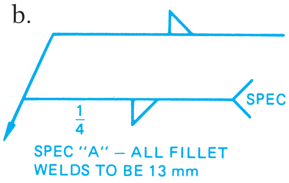
1. For the following items, select those metric expressions that are presented incorrectly and revise them so they are correct.
   - a. 4¾ mm ____________
   - b. .10 mm ____________
   - c. 18.67 mm ____________
   - d. 16 ± .05 mm ____________
   - e. 16½ mms. ____________
   - f. All tolerances, unless otherwise specified, are $^{+.10}_{-.10}$ mm ____________
   - g. 100 mm × 10 m × 25 mm ____________
   - h. 30 mm dia. × 20 mm ____________
   - i. 12,750 mm ____________
   - j. 0.7 millimeters ____________
2. Correct the element shown in the following welding symbols so they are consistent with metric dimensioning practices. Apply the elements as they should appear to the incomplete welding symbols shown on the right.

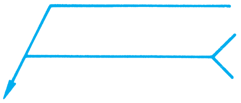
a.



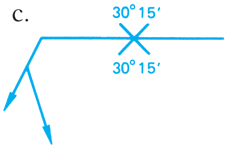


b.





c.



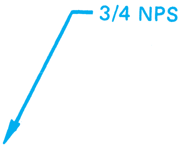
3. Fill in the missing elements in the following table.

Name	Quantity Represented	Symbol
_____	length	m
ampere	_____	_____
_____	_____	kg
_____	_____	K
Celsius	_____	_____
_____	_____	mm^2
volt	_____	_____
_____	_____	rad

4. a. What is the included angle of a radian? ____________

   b. Does it apply to the measurement of plane angles or solid angles? ____________
5. What is the preferred method for showing the following dimensions on a metric drawing?
   - a. 26° 35′ 22″ ____________
   - b. .758″ ____________
   - c. 0.08736 mm ____________
   - d. 68½ square inches ____________
6. What is the included angle of a metric screw thread form? ____________
7. Interpret the significance of each element of the following screw thread designations.

a.



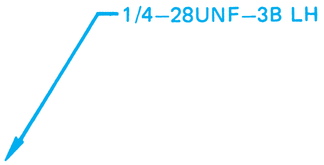
____

____

____

____

b.

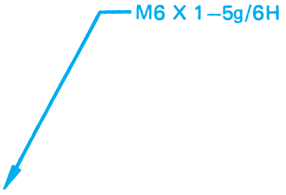


____

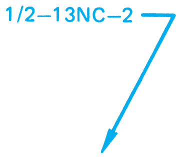
____

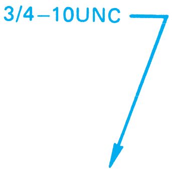
____

c.



d.





8. Make the following conversions.

   a. 2.500″ = ____________ mm

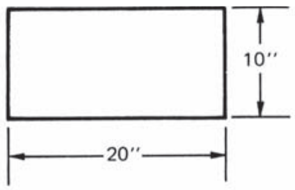
   b. 6 square inches = _____ square millimeters

   c. 2.2 radians = _________ degrees

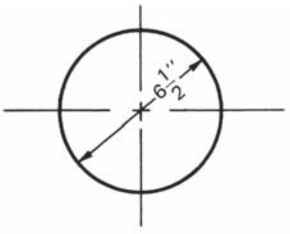
   d. 0.8 radian = _________ degrees

9. What is the area in square millimeters for the following shapes? Round answers to one decimal place.

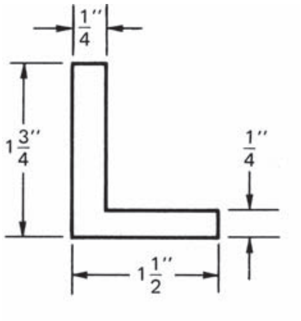
   a.



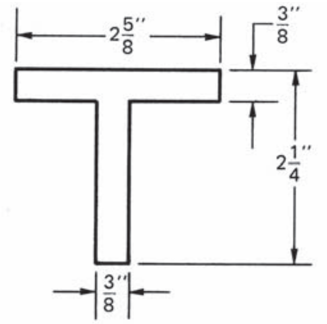
   b.



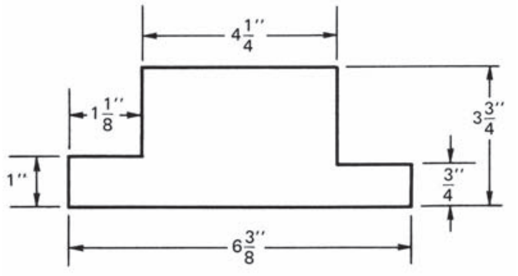
c.



d.

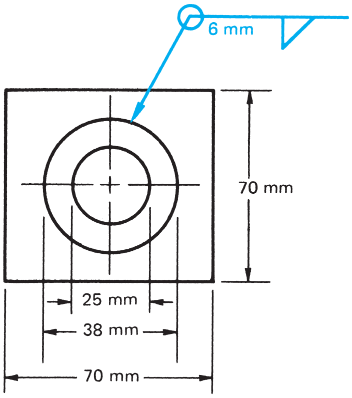


e.

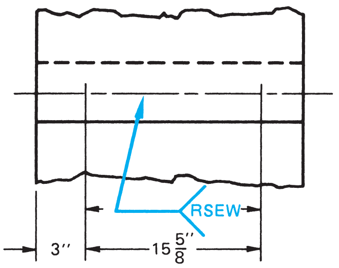


10. How many millimeters of weld are required in each of the following sketches? Round answers to nearest millimeter.

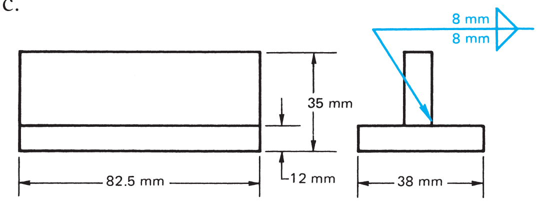
   a.



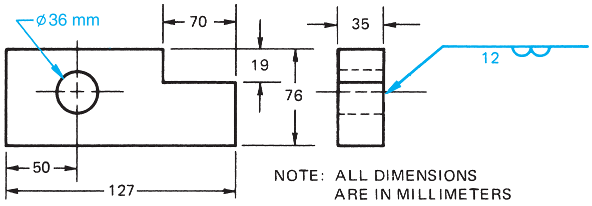
b.



c.



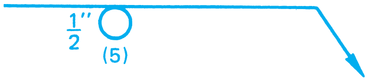
11. How many square millimeters of surface weld are required? Do not include the area of the hole. Round answer to nearest millimeter.



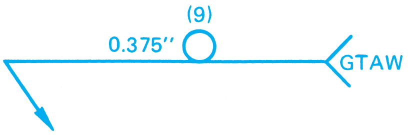
NOTE: ALL DIMENSIONS ARE IN MILLIMETERS

12. What is the size of each of the following welds in millimeters? Round answers to the nearest millimeter.

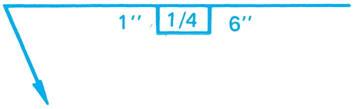
a.



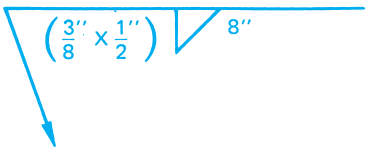
b.



c.

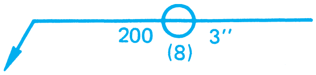


d.

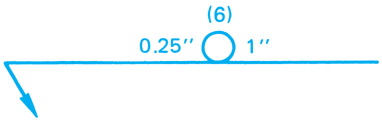


13. What is the spacing of each of the following welds in millimeters? Round answers to the nearest millimeter.

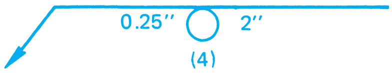
a.



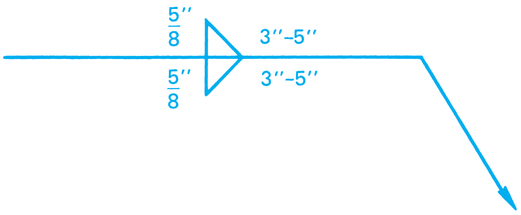
b.



c.



14. What is the pitch and length of the following welds in millimeters? Round answers to the nearest millimeter.

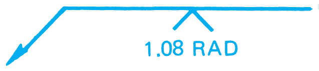


Pitch

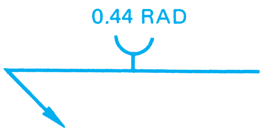
Length

15. How many degrees are indicated for each of the following angular dimensions? Round answers to the nearest degree.

a.



b.

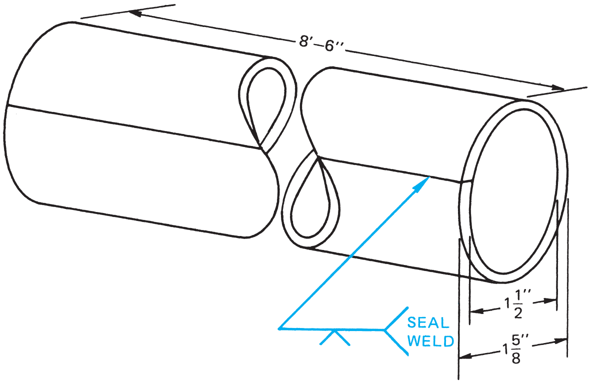


16. a. What is the volume in cubic millimeters of the cylinder illustrated? Round answer to the nearest cubic millimeter.

____

b. How many millimeters of weld are required to fabricate the cylinder? Round answer to nearest millimeter.

____



17. a. What is the area in square millimeters circumscribed by the broken lines in the following sketch at the top of next column? Round answer to the nearest square millimeter.

____

b. What is the perimeter of the area circumscribed by broken lines? Round answer to nearest millimeter.

____

c. What kind of weld is required?

____

____

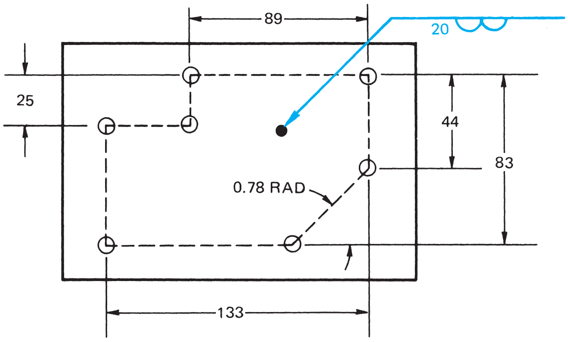
d. What does the number 20 applied to the welding symbol signify?

____

____

e. How many cubic millimeters of weld are required?

____

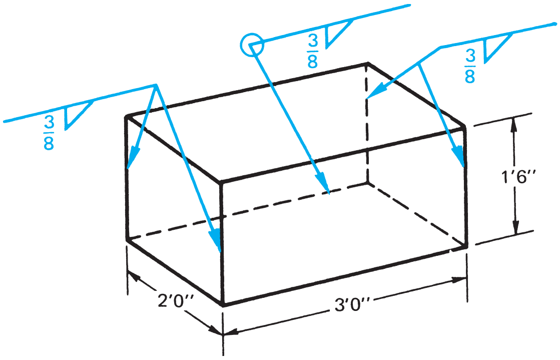


Note: All linear and welding symbol dimensions are in millimeters.

18. a. What is the volume in cubic millimeters of the tank illustrated below? Round answer to the nearest cubic millimeter. ______________

b. How many millimeters of weld would be required to fabricate the tank, assuming all sides and the bottoms are separate pieces? The top is open. Round answer to the nearest millimeter. ____________________

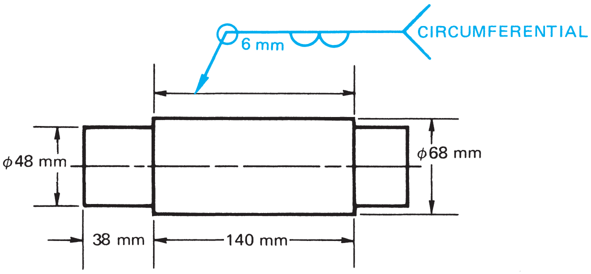
c. Add dual dimensions to each of the welding symbols in U.S. Customary units.



19. a. In the following sketch, how many cubic millimeters of weld will be deposited on the surface to be welded? Round answer to nearest cubic millimeter. ________________

b. On the sketch, show how the welded surface would appear in terms of "circumferential."

c. List the U.S. Customary dimensions that may be added to the mm dimensions.



20. a. The base of the pyramid in the following sketch has equal sides. Its area measures 1452 square millimeters. How many millimeters of fillet weld are required around the base of the pyramid? Round answer to nearest millimeter.

____

b. How many cubic millimeters are contained in the pyramid? Round answer to the nearest cubic millimeter. The height of the pyramid is 127 millimeters.

Note: The formula for calculating the volume of a pyramid is as follows: ⅓ × area of base × height of pyramid = volume.

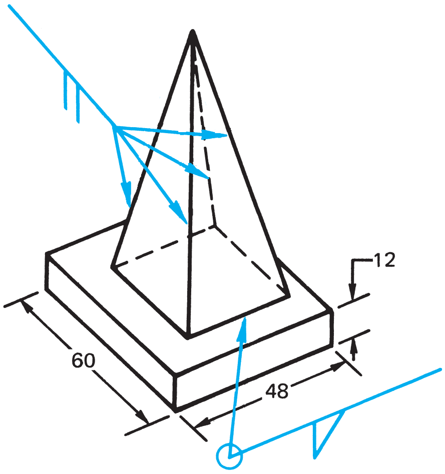
____

c. What is the length of the square groove weld for each of the edge joints of the pyramid? Round answer to the nearest millimeter.

Note: The formula for finding the hypotenuse of a triangle is as follows: height squared + base squared equals hypotenuse squared ($a^2 + b^2 = c^2$).

____

d. How many cubic millimeters are contained in the rectangular member?



NOTE: DIMENSIONS ARE IN MILLIMETERS.

21. Convert the answers to 20a., b., c., and d. to U.S. Customary units.

a. ________________ b. ________________

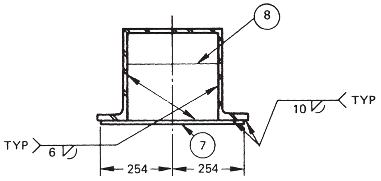
c. ________________ d. ________________

22. Convert the answers to questions 21a., b., c., and d. to U.S. Customary units.

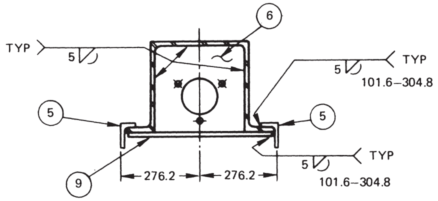
a. ________________ b. ________________

c. ________________ d. ________________

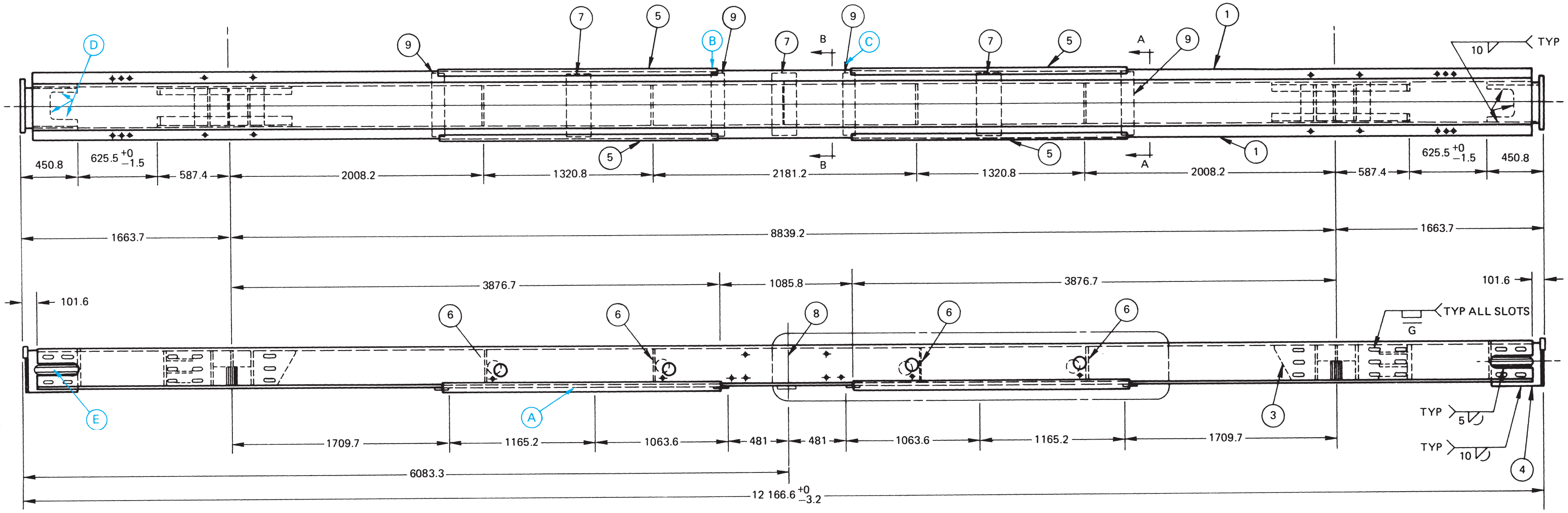
QUANT/ASSY	PART NO	DESCRIPTION	ITEM
2	2D743	CENTER SILL	1
			2
2	A4D343A	CENTER BRACE	3
2	A8D189	STRIKER	4
4	38B236B	SIDE REINFORCING	5
4	9B33	CENTER SILL SEPARATOR	6
3	9A34	CENTER SILL TIE STRAP	7
1	9A35	CENTER SILL SEPARATOR	8
4	38A262	HOPPER END CONNECTION	9



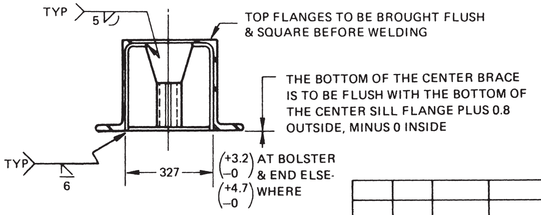
SECTION B-B



SECTION A-A



SILLS MUST BE WATERPROOF AND HAVE A MINIMUM GROOVE WELD SIZE OF 60% OF THE JOINT THICKNESS, WITH AN ULTIMATE TENSILE STRENGTH ACROSS THE WELD OF 40,000 PSI. WHERE COVER PLATE, ETC., ARE TO BE APPLIED TO THE TOP SURFACE, THE WELD MUST BE GROUND SMOOTH. WHERE THE CENTER SILL SECTIONS ARE AUTOMATICALLY WELDED THE GROOVE WELD SIZE IS TO BE A MINIMUM OF 75%. AT BOLSTERS, THE GROOVE WELD SIZE IS TO BE 100% FOR A MINIMUM DISTANCE OF 609.6 ON EACH SIDE OF BOLSTER CENTER LINE.



TYP 5
TOP FLANGES TO BE BROUGHT FLUSH & SQUARE BEFORE WELDING
THE BOTTOM OF THE CENTER BRACE IS TO BE FLUSH WITH THE BOTTOM OF THE CENTER SILL FLANGE PLUS 0.8 OUTSIDE, MINUS 0 INSIDE
TYP
6
327
(+3.2 −0) AT BOLSTER & END ELSE-WHERE (+4.7 −0)

NOTE:
ALL DIMENSIONS ARE IN MILLIMETERS (mm) ROUNDED OFF TO ONE DECIMAL PLACE

CENTER SILL ASSEMBLY		
REF. DWG. A2D664	PREPARED BY	CHECKED BY D. R.
CORRECT Dan	APPROVED	
SCALE 3/4" = 1'-0"	DRAWING	
DATE	A2D744	

REV	BY	DATE	REVISION
A			ITEM 1 WAS 1 PER ASS'Y & ITEM 2 REMOVED

EDITOR'S NOTE: REDUCED PRINT, FOLLOW STATED DIMENSIONS ONLY. NOT TO BE SCALED.

A LARGER DRAWING IS PROVIDED AT THE BACK OF THE TEXT.

UNIT 22: REVIEW B

Refer to the drawing, Center Sill Assembly, page 267.

Graph paper is provided at the end of this review for your use.

1. Identify the views shown on the drawing.

   ____

2. Item Ⓐ is identified as:

   ____

3. If automatic welding is carried out on the center sill, the penetration at the bolsters is to be ______________________ %.

4. Describe the welds required to join item 5 to item 1.

   ____

   ____

   ____

5. a. The total overall length of the assembled center sill in millimeters is __________.

   b. The tolerance allowed on the above dimension in millimeters is __________.

6. The distance from corner Ⓑ to corner Ⓒ is __________.

7. Part #9A34 is known as ______________.
   It is identified as item ______________
   and the quantity required is ____________.

8. How many of item #9 are required for each assembly?

   ____

9. How many center sill separators are required per assembly?

   ____

10. What is the length of item 1 in millimeters?

    ____

11. What must the ultimate tensile strength be across the weld for the sills?

    ____

12. a. The bottom of item 3 is to be flush with the bottom of the ______________________.

    b. Describe the finish and method of finish required at the weld required to join the items in 14(a).

    ____

13. What is the leg length in millimeters of the 5-mm fillet welds?

    ______________________________________ .

14. Describe the welds required to join the center sill separator to the center sill.

    ____

    ____

    ____

15. Describe the welds required at Ⓓ.

    ____

    ____

    ____

16. Describe the welds required at Ⓔ.

    ____

    ____

    ____

17. a. What is the size of the fillet welds to be applied as shown in Section A-A?

    ____

    b. What would this size be in inches?

    ____

    c. What is the contour specified for the fillet welds indicated in Section B-B?

    ____

UNIT 23

Pipe-Welding Symbols

SYMBOLS FOR PIPE LAYOUTS

Pipe layouts are shown through the use of single-line and double-line drawings. These drawings use special sets of symbols to identify the components of piping systems, including pipe, valves, fittings, flanges, and equipment. Figure 23.1 illustrates symbols developed and published by the American Society of Mechanical Engineers for this purpose.

In addition to these symbols, a number of companies have developed their own sets of symbols, both for single-line and double-line drawings. An example of a set of symbols developed by a company is shown in Figure 23.2. Note that the company's symbols provide for single-line and double-line representations.

The sampling of symbols shown in Figure 23.3 is provided to show that reference to special charts for symbol interpretation will be necessary when fabricating pipe layouts that use company symbols. Such charts are usually available from the company that designs the layout and/or provides the components for the layout. The length of the stud is shown on a detailed drawing.

Special symbols have also been developed to indicate the methods to be used for connecting the components of a pipe assembly, Figure 23.3. Note that the methods shown apply primarily to single-line drawings.

Single-line drawings are generally used to show pipe layouts for nominal pipe sizes of less than 12″, Figure 23.4(a) and (b). However, this practice will vary from company to company. At times, layouts using smaller pipe sizes may be shown as double-line drawings.

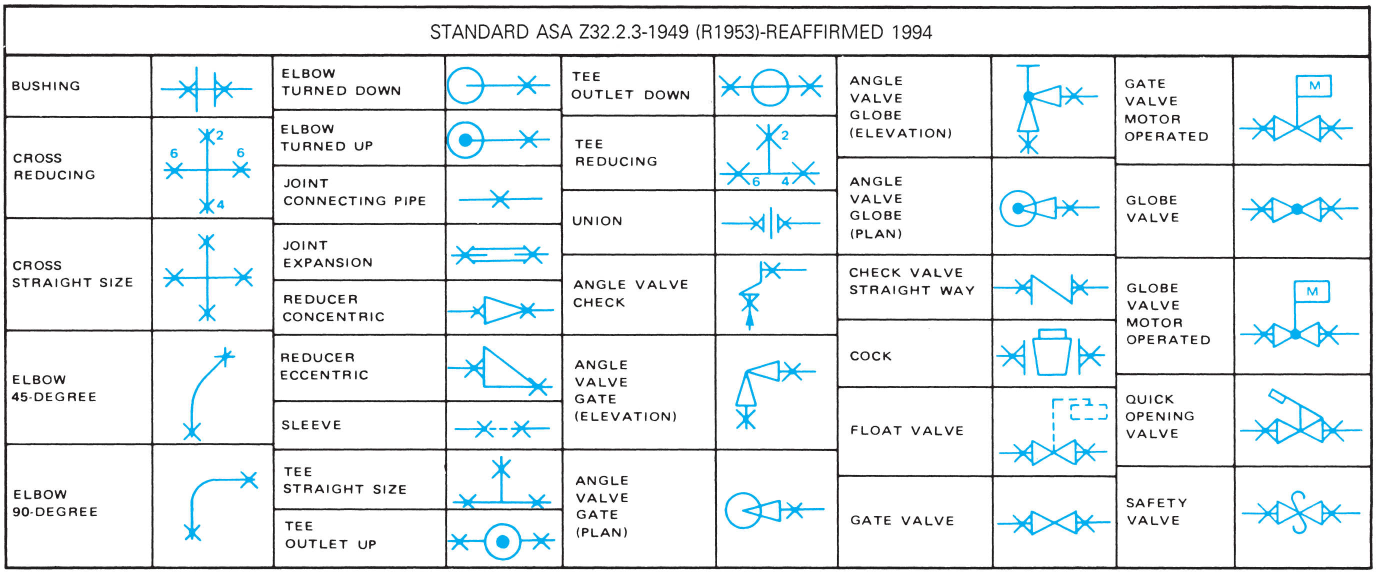


FIGURE 23.1 ■ Fitting and valve symbols for pipe fabrications used on welding drawings.

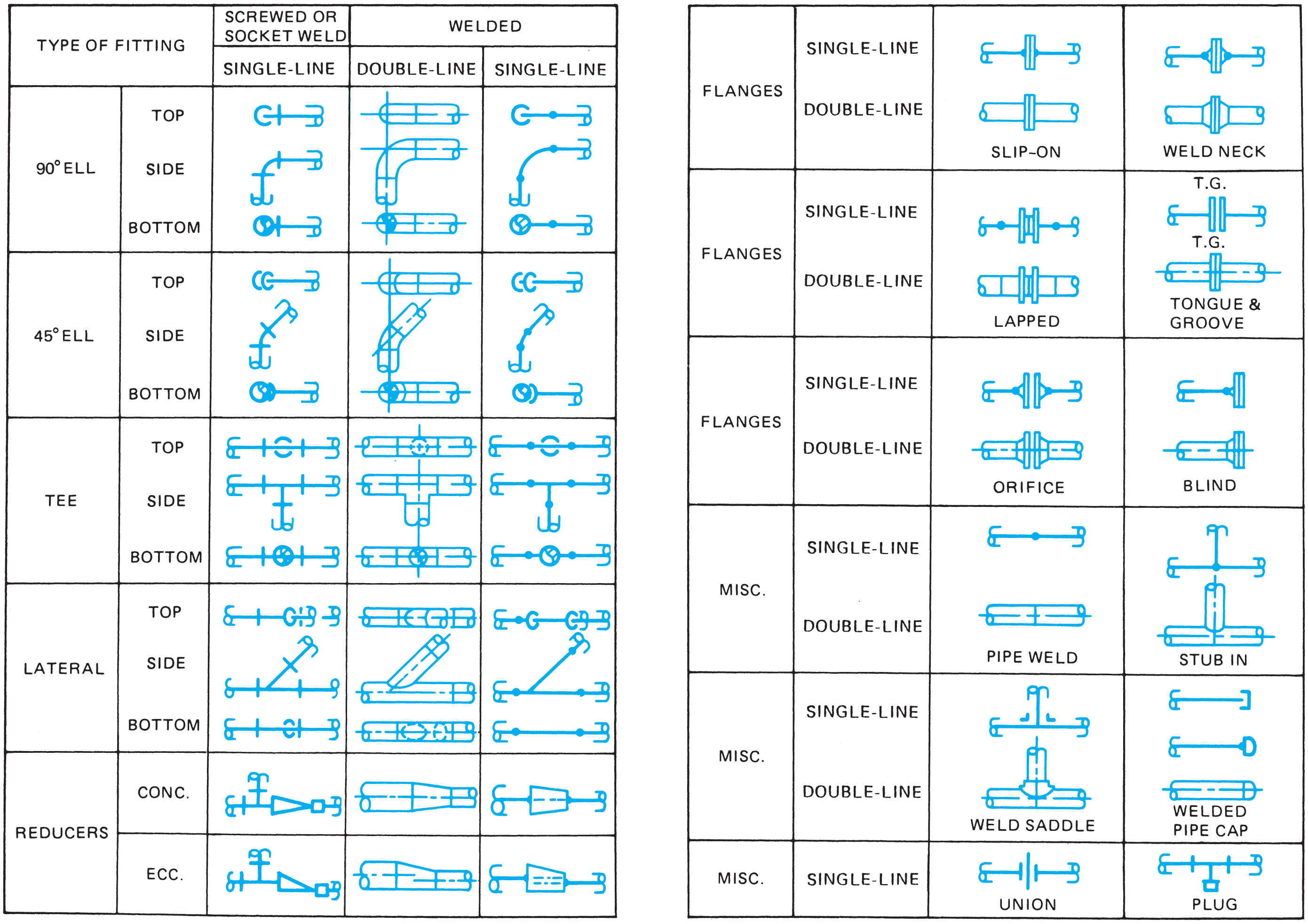
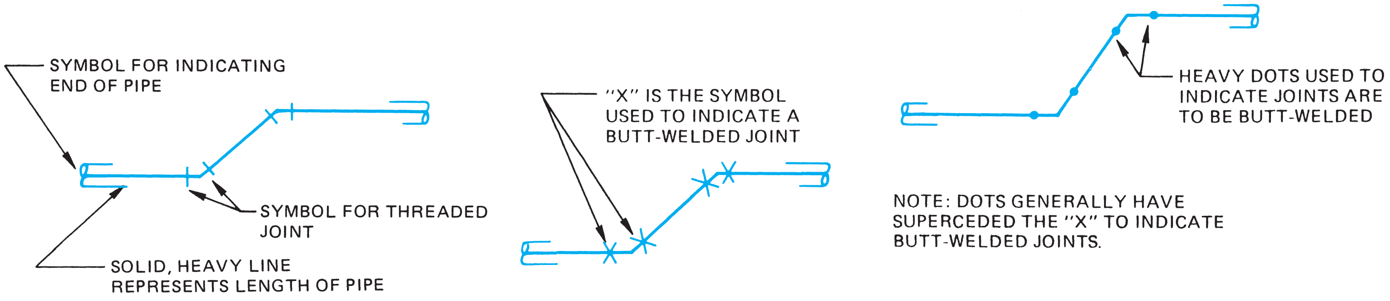


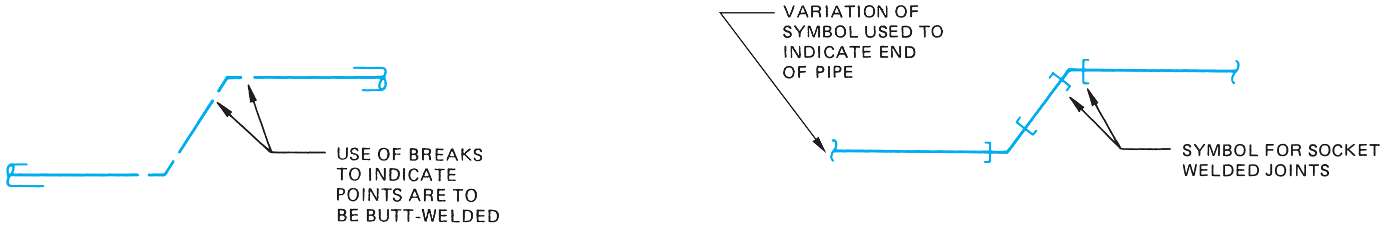
FIGURE 23.2 ■ Example of a set of symbols for fittings and flanges developed by a company for use on pipe drawings.


SYMBOL FOR INDICATING END OF PIPE
SYMBOL FOR THREADED JOINT
SOLID, HEAVY LINE REPRESENTS LENGTH OF PIPE
"X" IS THE SYMBOL USED TO INDICATE A BUTT-WELDED JOINT
HEAVY DOTS USED TO INDICATE JOINTS ARE TO BE BUTT-WELDED
NOTE: DOTS GENERALLY HAVE SUPERCEDED THE "X" TO INDICATE BUTT-WELDED JOINTS.

(a) CONVENTIONAL SYMBOL FOR INDICATING A THREADED JOINT.

(b) CONVENTIONAL METHOD FOR INDICATING A BUTT-WELDED JOINT.

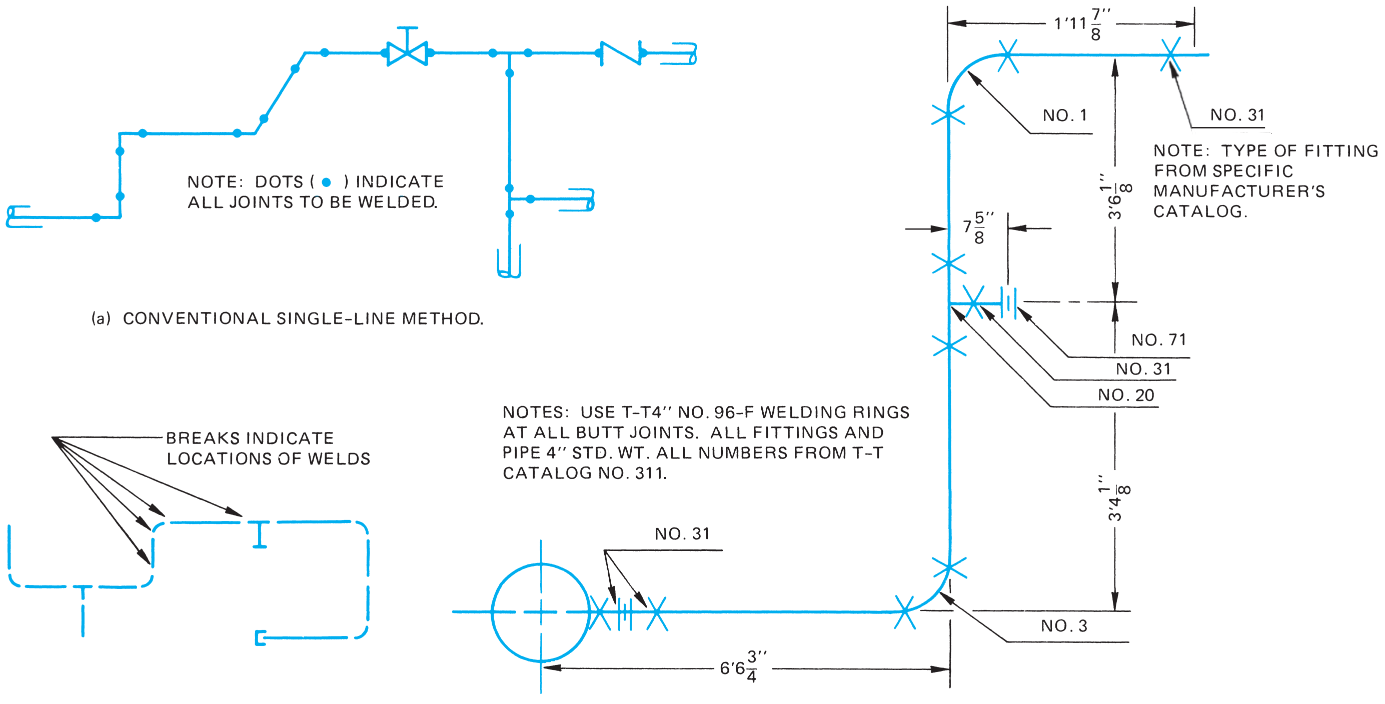
(c) SIMPLIFIED METHOD TO INDICATE A BUTT-WELDED JOINT.


USE OF BREAKS TO INDICATE POINTS ARE TO BE BUTT-WELDED
VARIATION OF SYMBOL USED TO INDICATE END OF PIPE
SYMBOL FOR SOCKET WELDED JOINTS

(d) ANOTHER SIMPLIFIED METHOD USED TO INDICATE A BUTT-WELDED JOINT.

(e) CONVENTIONAL METHOD OF INDICATING SOCKET WELDED JOINTS.

FIGURE 23.3 ■ Symbols used on single-line pipe layout drawings to indicate the method to be used to connect joints.


NOTE: DOTS (●) INDICATE ALL JOINTS TO BE WELDED.
(a) CONVENTIONAL SINGLE-LINE METHOD.
BREAKS INDICATE LOCATIONS OF WELDS
NOTES: USE T-T4'' NO. 96-F WELDING RINGS AT ALL BUTT JOINTS. ALL FITTINGS AND PIPE 4'' STD. WT. ALL NUMBERS FROM T-T CATALOG NO. 311.
1'11 7/8''
NO. 1
NO. 31
NOTE: TYPE OF FITTING FROM SPECIFIC MANUFACTURER'S CATALOG.
3'6 1/8''
7 5/8''
NO. 71
NO. 31
NO. 20
3'4 1/8''
NO. 31
NO. 3
6'6 3/4''

(b) CONVENTIONAL SINGLE-LINE METHOD.

FIGURE 23.4 ■ Examples of single-line pipe layouts.

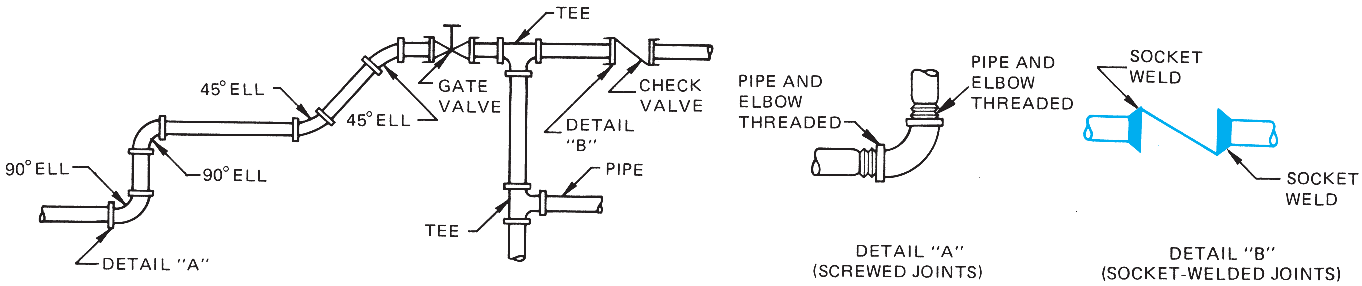


FIGURE 23.5 ■ Double-line pipe layout.

Double-line drawings are used for pipe layouts that use large sizes of pipe and fittings (12″ and over) and for complex pipe layouts. In the case of complex layouts, the pipe size may be less than 12″. A double-line pipe layout may specify several methods of connecting the pipe and fittings, Figure 23.5.

When pipe and fittings are to be butt welded, the ends are beveled. For joints that are socket welded, the ends are squared, Figure 23.6.

It should be noted that valves and fittings, as a rule, are shown on double-line drawings by the same symbols used for single-line drawings, Figure 23.7. Simple fittings, such as elbows and tees, are pictorially represented, using either a conventional or simplified method of representation.

Double-line drawings may include use of the standard welding symbols to indicate the kinds of welds required for assembling the components of the pipe layout, Figure 23.8(a) and (b).

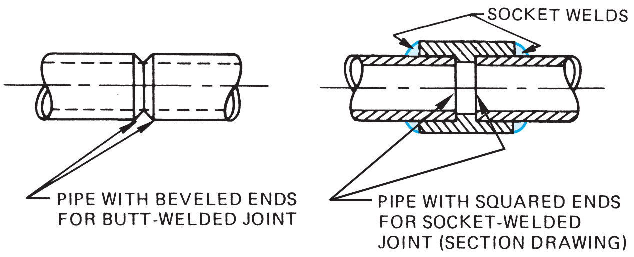

SOCKET WELDS
PIPE WITH BEVELED ENDS FOR BUTT-WELDED JOINT
PIPE WITH SQUARED ENDS FOR SOCKET-WELDED JOINT (SECTION DRAWING)

FIGURE 23.6 ■ Preparation of pipe ends for butt- and socket-welded joints.

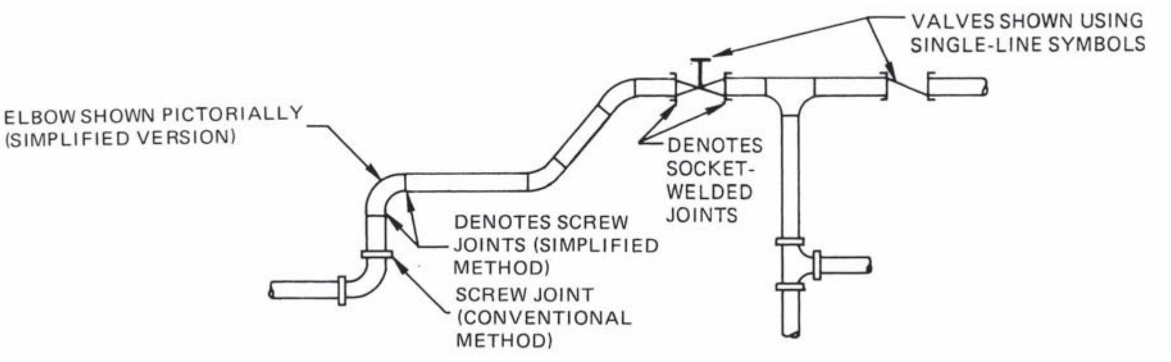
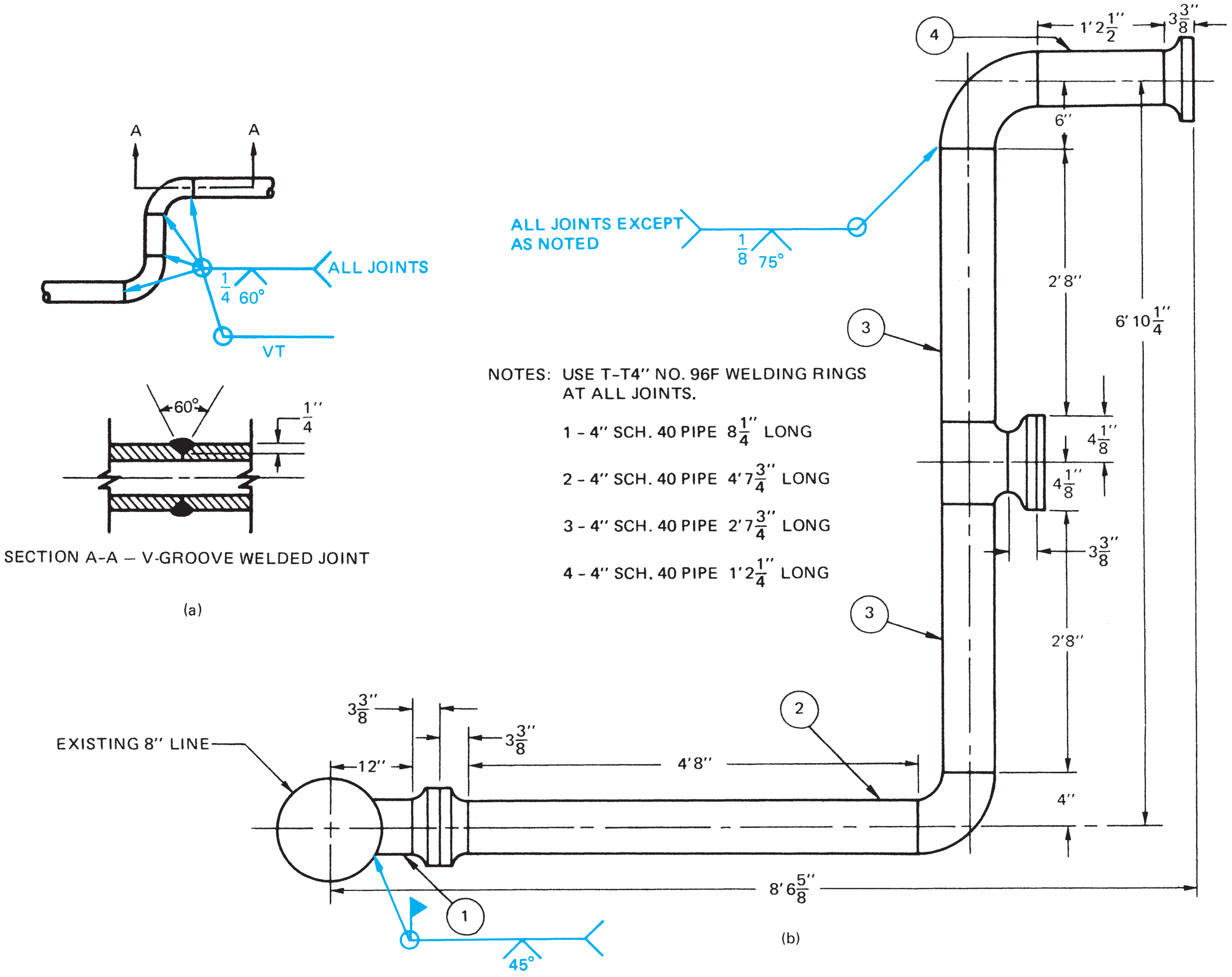

VALVES SHOWN USING SINGLE-LINE SYMBOLS
ELBOW SHOWN PICTORIALLY (SIMPLIFIED VERSION)
DENOTES SOCKET-WELDED JOINTS
DENOTES SCREW JOINTS (SIMPLIFIED METHOD)
SCREW JOINT (CONVENTIONAL METHOD)

FIGURE 23.7 ■ Methods for showing fittings and valves on double-line drawings.



NOTES: USE T-T4″ NO. 96F WELDING RINGS AT ALL JOINTS.

1 - 4″ SCH. 40 PIPE 8 1/4″ LONG

2 - 4″ SCH. 40 PIPE 4′7 3/4″ LONG

3 - 4″ SCH. 40 PIPE 2′7 3/4″ LONG

4 - 4″ SCH. 40 PIPE 1′2 1/4″ LONG

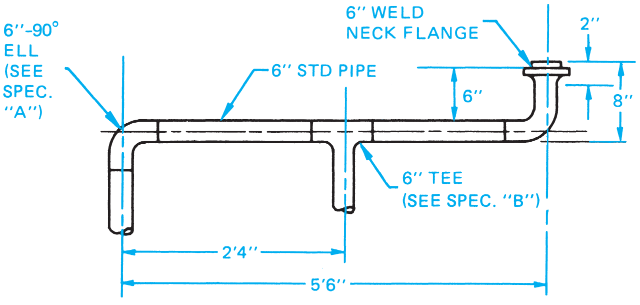
FIGURE 23.8 ■ Double-line representation of pipe layout using conventional welding symbols.

DIMENSIONING PIPE LAYOUTS

The runs of pipe on a pipe layout are shown without any indication of pipe sizes. This is also true for fittings and valves. Dimensioning for such components is accomplished by the addition of specifications and notes to the drawings. However, length, height, and location dimensions are shown on the drawing. Location dimensions are applied to the centerlines of the pipe and fittings to serve as reference points for locating items in the layout, Figure 23.9(a) and (b). Dimensions are usually expressed in feet and inches when they measure more than one foot.

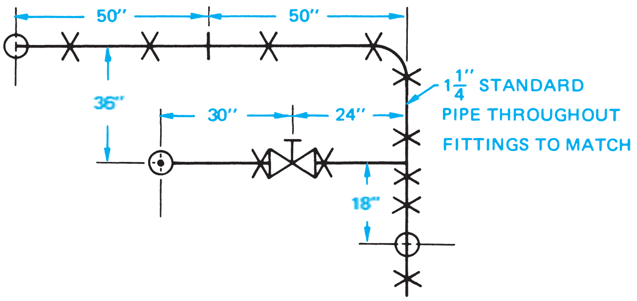
METHODS OF REPRESENTING A PIPE LAYOUT

A pipe layout can be represented by any number of orthographic views, Figure 23.10(a); by an oblique view, Figure 23.10(b); or by an isometric view, Figure 23.10(c) and Figure 23.11(a), and Figure 23.11(b). Note that each of the methods shown in the figure illustrates the same pipe layout.



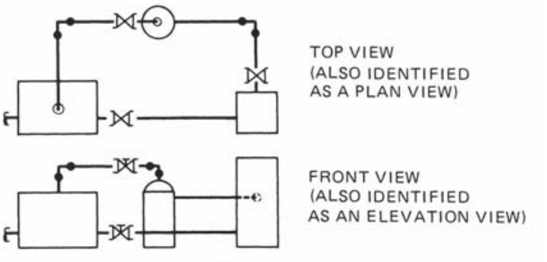
SPEC. "A" ALL 90° ELLS WITH LONG RADIUS AND STD BORE
"B" ALL TEES TO BE STRAIGHT WITH STD BORE

(a) DIMENSIONS APPLIED TO A DOUBLE-LINE LAYOUT.

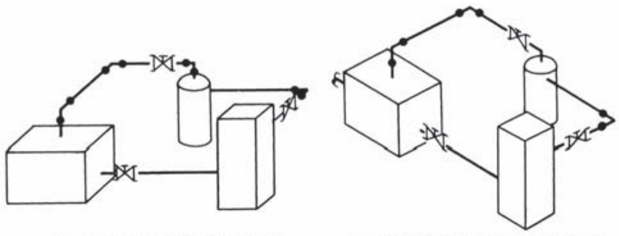


(b) DIMENSIONS APPLIED TO A SINGLE-LINE LAYOUT.

FIGURE 23.9 ■ Typical dimensioning practices.


TOP VIEW (ALSO IDENTIFIED AS A PLAN VIEW)
FRONT VIEW (ALSO IDENTIFIED AS AN ELEVATION VIEW)

(a) ORTHOGRAPHIC VIEWS.



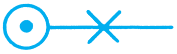
(b) SINGLE-LINE OBLIQUE VIEW OF PIPE LAYOUT.

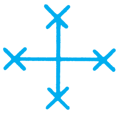
(c) SINGLE-LINE ISOMETRIC VIEW OF PIPE LAYOUT.

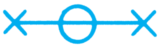
FIGURE 23.10 ■ Methods of representing a pipe layout.

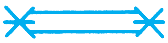
UNIT 23: REVIEW

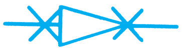
1. Identify the pipe fittings and/or valves represented by the following symbols.

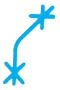
a.  ______________________

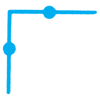
b.  ______________________

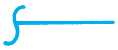
c.  ______________________

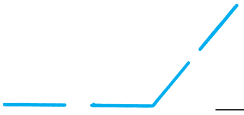
d.  ______________________

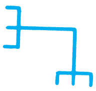
e.  ______________________

f.  ______________________

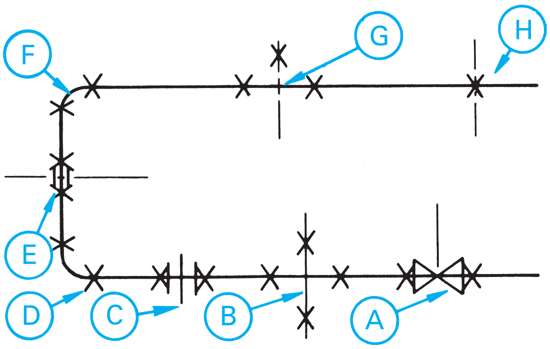
g.  ______________________

h.  ______________________

i.  ______________________

j.  ______________________

2. a. Apply the dimensions and notes that would be required for the pipe layout as follows. Assume any sizes desired.



b. Identify each welded pipe fitting, Ⓐ through Ⓗ, given on the pipe layout.

Ⓐ ______________________

Ⓑ ______________________

Ⓒ ______________________

Ⓓ ______________________

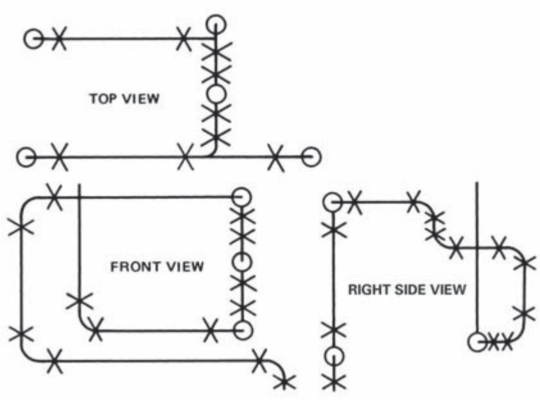
Ⓔ ______________________

Ⓕ ______________________

Ⓖ ______________________

Ⓗ ______________________

3. Develop a right isometric drawing from the three-view orthographic drawing given.



4. Figure 23.11(a) is a single-line representation of the typical pipe layout for a heating system, Figure 23.11(b), shown on page 278. However, several modifications were made in the single-line figure to illustrate additional common fittings.

a. Identify the pipe fittings represented by symbols Ⓐ through Ⓙ.

Ⓐ ______________________

Ⓑ ______________________

Ⓒ ______________________________

Ⓓ ______________________________

Ⓔ ______________________________

Ⓕ ______________________________

Ⓖ ______________________________

Ⓗ ______________________________

Ⓘ ______________________________

Ⓙ ______________________________

b. Name two fittings included in Figure 23.11(a) that are not shown in Figure 23.11(b).

____

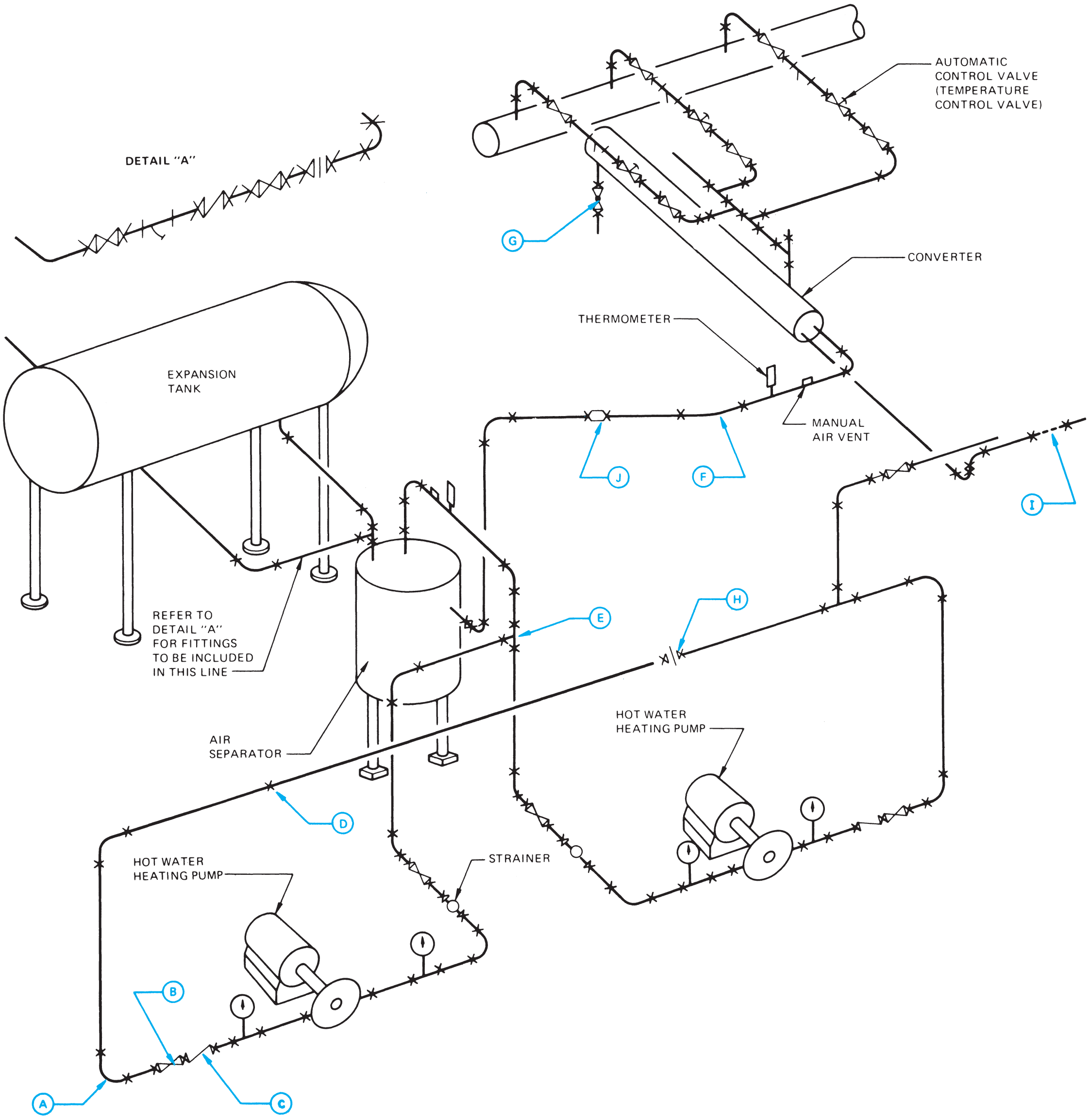


FIGURE 23.11(a) ■ Single-line pipe layout.

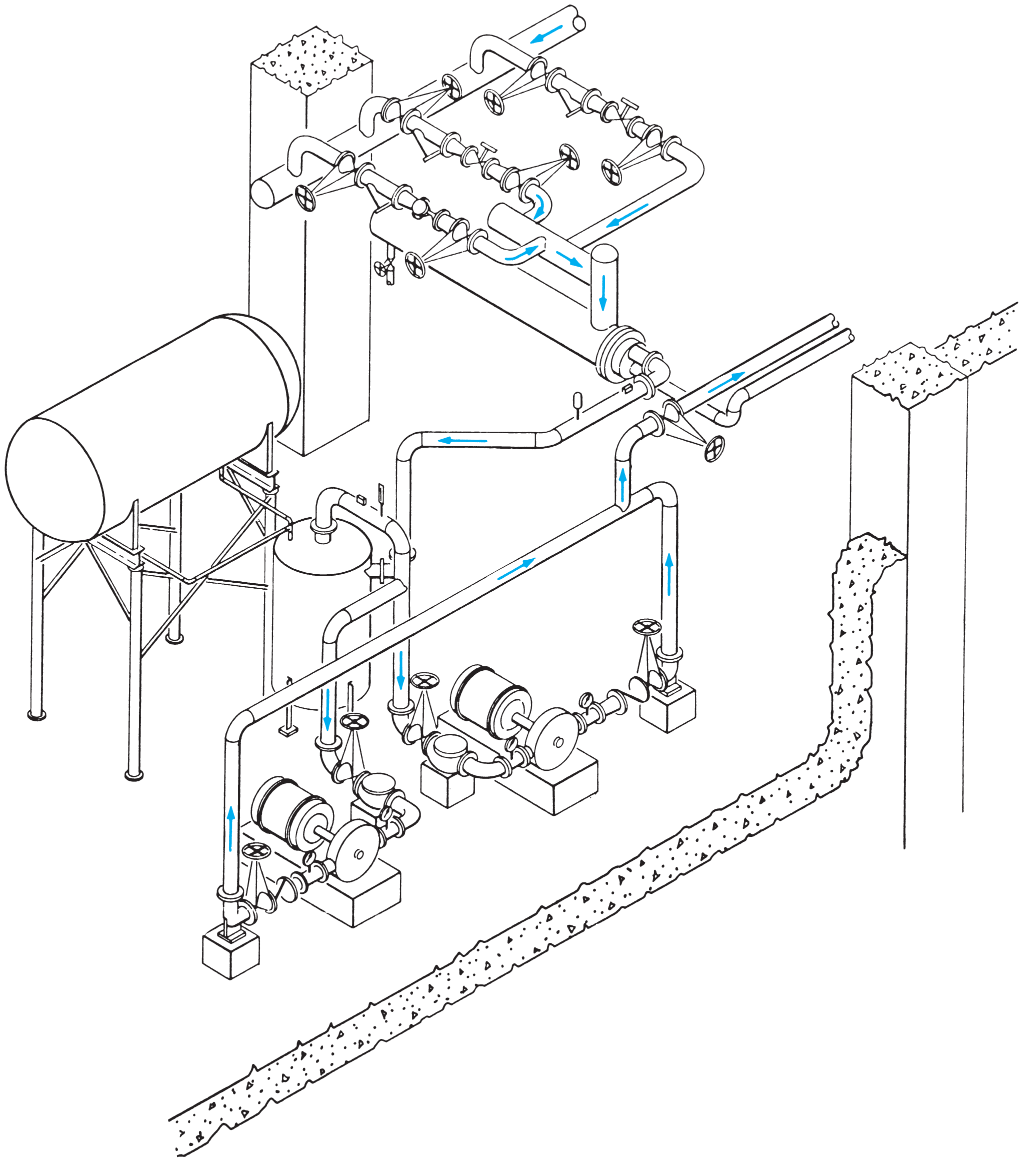
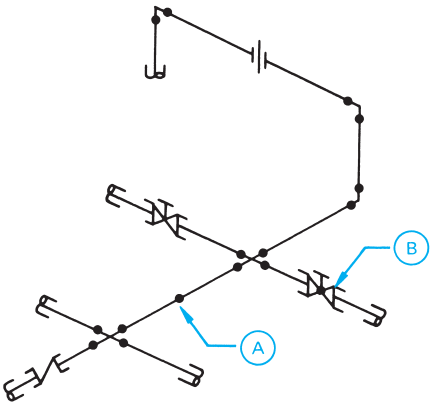


FIGURE 23.11(b) ■ Pictorial (isometric) pipe layout.

5. a. Prepare a two-view orthographic drawing from the isometric pipe layout that follows. Show a top view (plan view) and a front view (elevation view).



b. Identify the components shown in the layout.

____

____

____

____

c. Refer to 5a. and prepare sectional sketches showing how the welds will appear at points Ⓐ and Ⓑ.

d. Identify the type of joints required at Ⓐ and Ⓑ.

Ⓐ ______________________________

Ⓑ ______________________________

24 UNIT

Dual Dimensioning

Dual dimensioning is the use of dimensions in both the U.S. Customary (**inch**) and SI (**metric**) systems of measurement on drawings. This dimensioning technique is being used by many manufacturers during the transition period from the U.S. Customary (inch) system of measurement to the metric system. Manufacturers who market their products to international consumers also use dual dimensioning.

Dual-dimensioned prints are more costly to prepare; however, they permit greater flexibility in their application. Through the use of dual-dimensioned prints, parts that are to be manufactured to metric dimensions may be produced by using machines that are graduated in the inch system of measurement. Also, machines that are designed to manufacture metric-dimensioned parts may be used to produce parts that are specified in inches.

Dual dimensions are equivalent to one another to a degree of accuracy that will permit functional interchangeability of parts, regardless of the system of measurement used in producing them. The degree of accuracy between inch and metric dimensions is determined by the number of decimal places to which each dimension is rounded off. This same principle applies to tolerance dimensions.

The metric unit of measurement most commonly used on dual-dimensioned prints is the millimeter. However, the meter is also used in cases where dimensions are so large that it is impractical to show or perform the measurement in millimeters. For example, 18000 millimeters is best shown as 18 meters. Once a metric unit

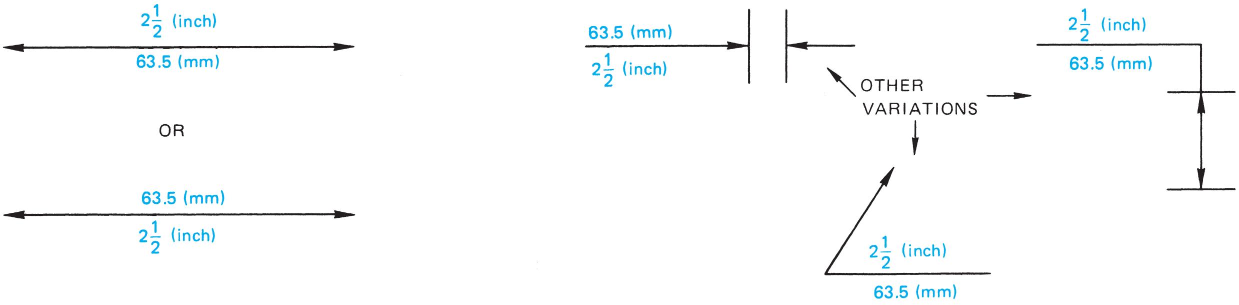


FIGURE 24.1 ■ Variations of the positioning method, utilizing a horizontal line, for dual dimensioning.

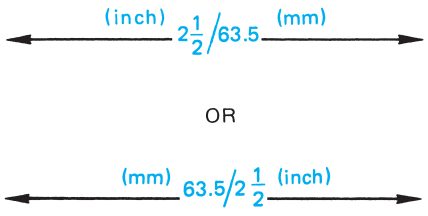
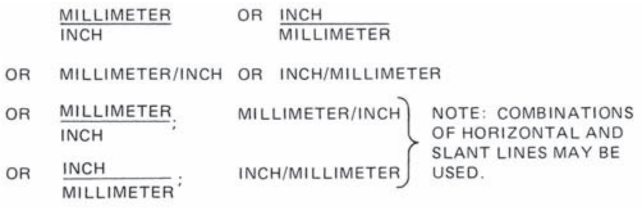


FIGURE 24.2 ■ Variations of the positioning method, utilizing a slash line, for dual dimensioning.



MILLIMETER / INCH OR INCH / MILLIMETER

OR MILLIMETER/INCH OR INCH/MILLIMETER

OR MILLIMETER / INCH ; MILLIMETER/INCH

OR INCH / MILLIMETER ; INCH/MILLIMETER

NOTE: COMBINATIONS OF HORIZONTAL AND SLANT LINES MAY BE USED.

FIGURE 24.3 ■ Typical notes used to indicate positioning arrangement of dual dimensions on a drawing.

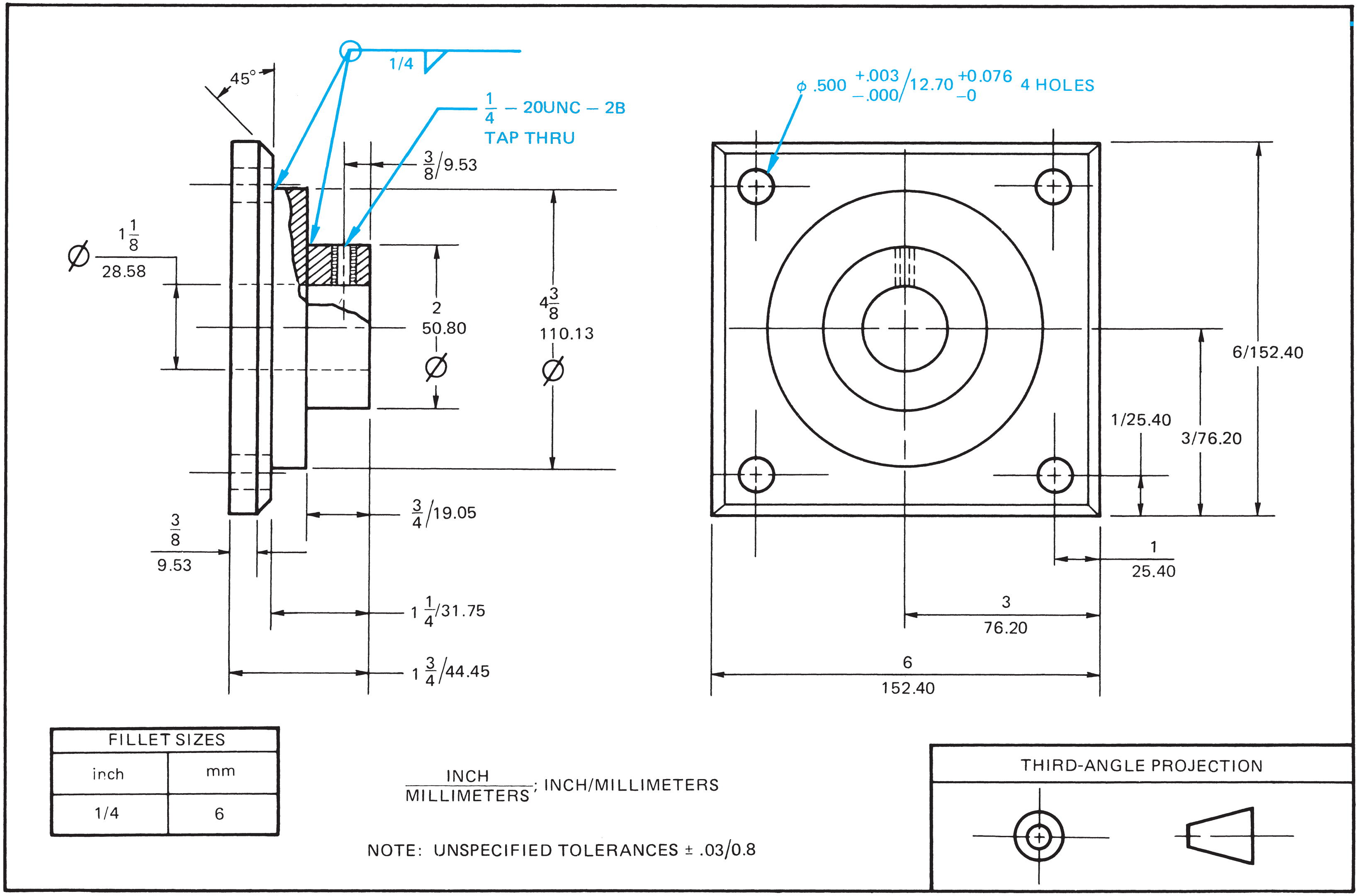


FIGURE 24.4 ■ Application of positioning method for dual dimensioning of a drawing using horizontal and slash lines.

is selected, it is used consistently throughout the drawing. The accompanying U.S. Customary unit of measurement may be given as a common or decimal fraction, but the decimal fraction is preferred. The application of common and decimal fractions is shown in Figure 24.4.

There are two standard methods used to distinguish the U.S. Customary (inch) unit from the SI (metric) unit when dual dimensions are applied. One method is known as the **positioning** method. When this method is used, the inch and metric dimensions are positioned in specific locations with respect to one another. The second method is known as the **bracket** method. In this method, either the inch or metric dimension is enclosed in brackets. Either method may be used on a drawing, but not both.

When the positioning method is used, the units are separated either by a horizontal line (usually a dimension line), Figure 24.1; or a slash line, Figure 24.2. Note the optional locations for the dual dimensions.

The positioning arrangement selected for dual dimensioning is indicated by a note on the drawing, Figure 24.3.

Refer to Figure 24.4 for a review of the application of the positioning method for dual dimensioning. Note the use of both the horizontal line and the slash line techniques for separating dimensions. The method selected will depend on which is most convenient for presenting a particular dimension.

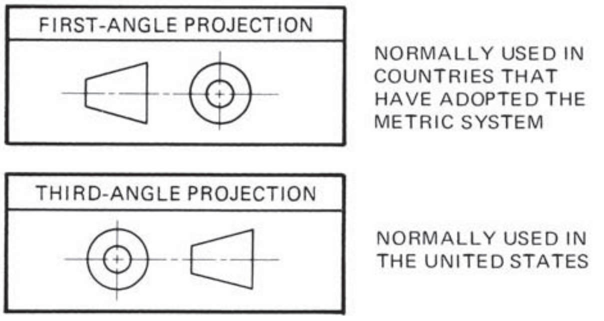

FIRST-ANGLE PROJECTION
NORMALLY USED IN COUNTRIES THAT HAVE ADOPTED THE METRIC SYSTEM
THIRD-ANGLE PROJECTION
NORMALLY USED IN THE UNITED STATES

FIGURE 24.5 ■ Symbols for designating angle of projection.

In reviewing Figure 24.4, note that the symbol ∅ is used to indicate a diameter rather than the abbreviation "DIA." However, it is standard practice to use "DIA" in a note. Note in the lower right-hand corner of the drawing that a symbol is shown to indicate the angle of projection. This is standard practice for dual-dimensioned drawings.

The angle of projection is indicated on a dual-dimensioned drawing when it is to have international applications.

Countries that use the metric system normally prepare drawings using first-angle projection. Drawings prepared in countries where the U.S. Customary system is used, show the views arranged in third-angle projection. To avoid confusion in the interpretation of dual-dimensioned drawings, the angle of projection symbol is shown, Figure 24.5. Observe that the views used in the symbol for first-angle and third-angle projection are the same, except that they are arranged differently.

In the bracket method for dual dimensioning, either the inch or metric dimension is enclosed in brackets. The bracketed unit may be located above or below, or to the right or left of the equivalent unit, Figure 24.6. Observe that one or both of the units is centered on the dimension line.

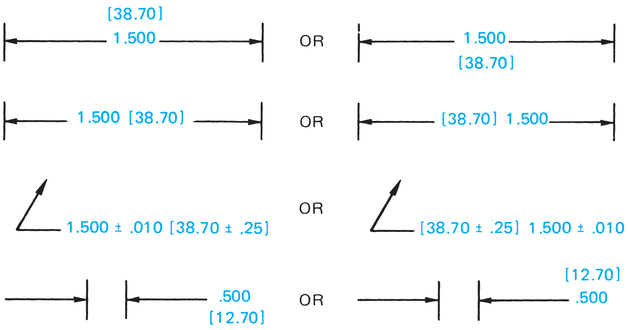


FIGURE 24.6 ■ Variations of the bracket method for dual dimensioning.

A note is shown on the print to indicate which unit is enclosed in brackets, Figure 24.7.

DIMENSIONS IN [ ] ARE IN INCHES.

OR

DIMENSIONS IN [ ] ARE IN MILLIMETERS.

FIGURE 24.7 ■ Typical notes used to indicate bracket method of dual dimensioning.

Refer to Figure 24.8 for a review of the application of the bracket method for dual dimensioning. Note that all of the dimensions are shown in decimal fractions. However, where common fractions are normally used for nominal sizes, such as thread and pipe sizes, the dimensions are shown as common fractions.

Dimensioning a drawing with decimal fractions has become standard practice. It is generally preferred for new drawings because it is easier to convert to metric dimensions, if necessary.

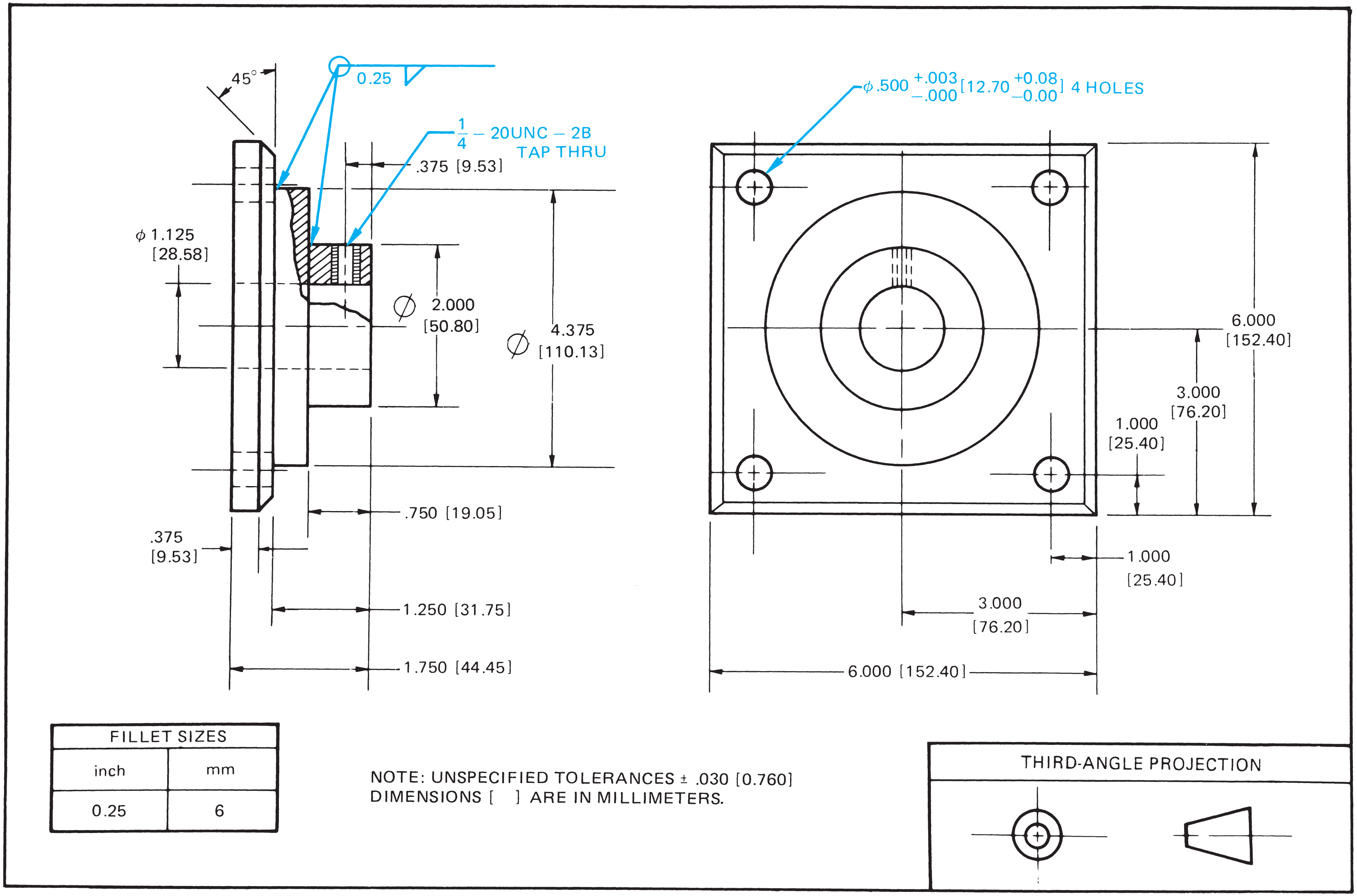


FIGURE 24.8 ■ Application of bracket method for dual dimensioning in a drawing.

Drawings dimensioned in common fractions are generally those that were not dual dimensioned originally. As the need arose, equivalent millimeter dimensions were added to the common fractions.

An alternative to the positioning and bracket methods for dual dimensioning is to provide a conversion chart on the print. Only one unit of measurement or a series of letters is shown on the print to represent the dimensions. A chart located on the print gives the equivalent dimension for the dimension or letter shown. In some cases, it is more practical to attach the conversion chart to the print as a separate document. Such charts can be computer-generated, thus simplifying the dual-dimensioning process.

Examples of methods used for displaying conversion tables are shown in Figure 24.9 and Figure 24.10. Note that dimensions shown in conversion charts are arranged in order of their value, usually from the smallest dimension to the largest. The reverse order may also be used.

In some cases, although conversions are necessary, they are not shown on the print. A note specifying the conversion factor to be used is included on the print. A typical example is:

Note: Convert inch dimensions to millimeter equivalents using the factor 25.4 (inch × 25.4 = millimeter equivalent), or inch × 22⁄7 = millimeter equivalent as a fraction.

Another method of converting dimensions is the direct reading of dual-dimensioned machine dials, Figure 24.11. This method eliminates the need for dual-dimensioned prints or conversion charts.

Note in Figure 24.9 and Figure 24.10 that a separate conversion chart for the fillet weld sizes is given. As shown on the chart, the millimeter dimension for the fillet size is rounded off to a whole number and the inch conversion is shown as a decimal fraction with a zero preceding the decimal point. These are standard practices applied to fillet conversion charts found on dual-dimensioned drawings.

Additional standards and practices applicable to dual-dimensioned drawings are:

- General tolerances applicable throughout the drawings are indicated by a note and in dual dimensions.

Example: Unspecified tolerances
inch→ ±.03/0.8 ←mm

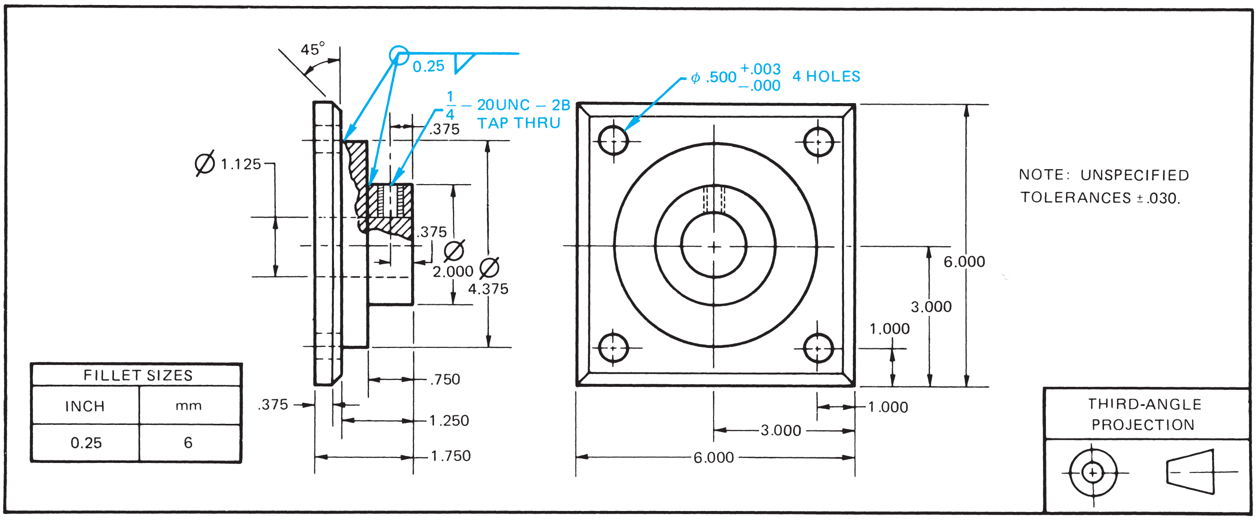
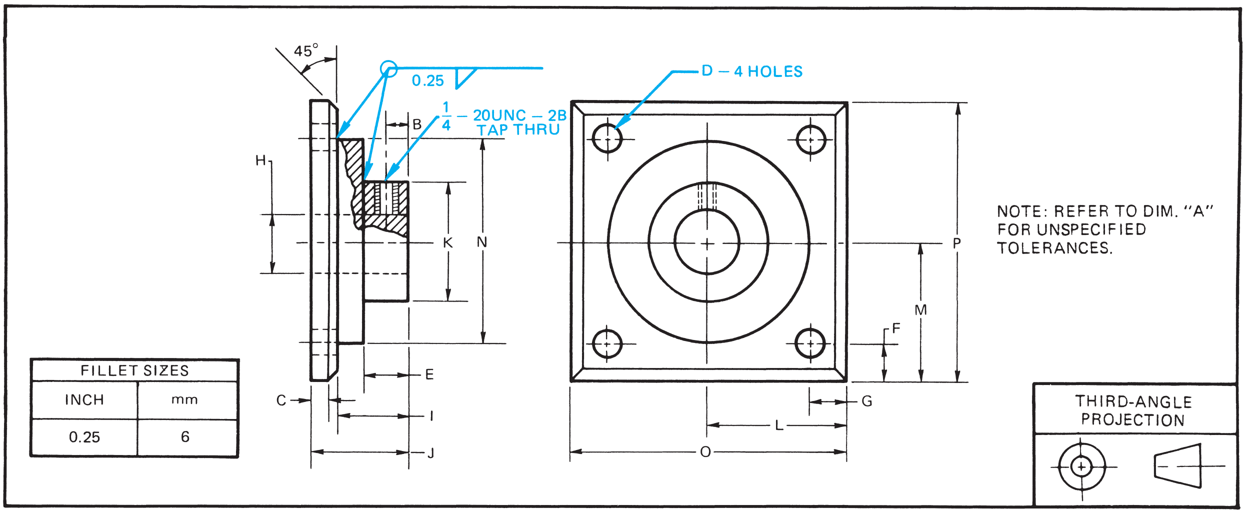


TABLE OF INCH/MILLIMETER EQUIVALENTS

INCH	.03	.375	Ø .500 $^{+.003}_{-.000}$	.750	1.000	1.000	Ø 1.125
mm	0.76	9.53	Ø 12.70 $^{+0.08}_{-0.00}$	19.05	25.40	25.40	Ø 28.58
INCH	1.250	1.750	Ø 2.000	3.000		Ø 4.375		6.000
mm	31.75	44.45	Ø 50.80	76.20		Ø 110.13		152.40

FIGURE 24.9 ■ Application of conversion table for dual dimensioning.



NOTE: REFER TO DIM. "A" FOR UNSPECIFIED TOLERANCES.

FILLET SIZES	
INCH	mm
0.25	6

TABLE OF INCH/MILLIMETER EQUIVALENTS

DIM.	A	B, C	D	E	F, G	H
INCH	.030	.375	⌀ .500 $^{+.003}_{-.000}$	.750	1.000	⌀ 1.125
mm	0.76	9.53	⌀ 12.70 $^{+0.08}_{-0.00}$	19.05	25.40	⌀ 28.58

DIM.	I	J	K	L, M	N	O, P
INCH	1.250	1.750	⌀ 2.000	3.000	⌀ 4.375	6.000
mm	31.75	44.45	⌀ 50.80	76.20	⌀ 111.13	152.40

FIGURE 24.10 ■ Application of conversion table for dual dimensioning by use of letters.

- Plus and minus tolerances are shown with the same number of decimal places.

Example: $25.4^{+0.15}_{-0.10}$

not $25.4^{+0.15}_{-0.1}$

- Angle dimensions indicated in degrees are common to the inch and metric systems, and, therefore, are not normally shown as dual dimensioned (in radians).
- Welding symbols are not usually dual dimensioned. Either the U.S. Customary unit or metric unit of measurement is applied, Figure 24.12. When an equivalent unit is required, a conversion table is included. Figure 24.10 and Figure 24.12(c) and (d) illustrate dual dimensioning followed by some companies. The same practice applies to testing symbols presented in Unit 25.
- If a metric dimension is a whole number (254), a decimal point and a 0 are not required.

Example: 254 not 254.0

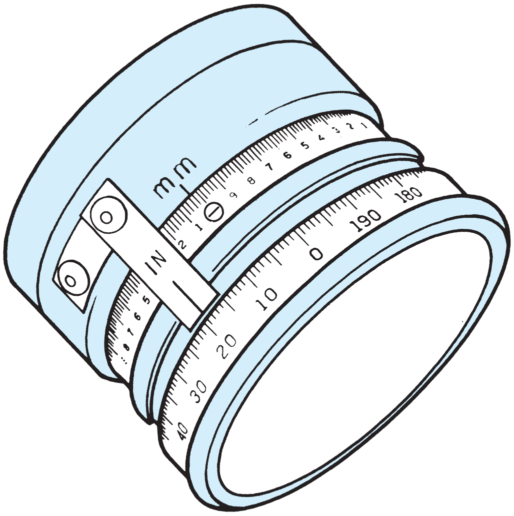
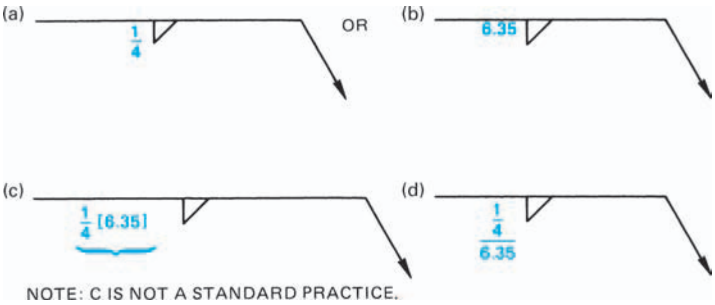


FIGURE 24.11 ■ Inch/metric dual dial.



NOTE: C IS NOT A STANDARD PRACTICE.

FIGURE 24.12 ■ Dimensioning practices used for welding symbols.

- If a conversion is needed and not shown on the print, the inch dimension may be multiplied by 25.4 or $\frac{22}{7}$ to obtain the millimeter equivalent.
- To convert a millimeter dimension to inches, divide it by 25.4 or $\frac{22}{7}$.
- In converting an inch value to a millimeter value, it is standard practice to show the millimeter value to one less decimal value than the original inch value.

Example: .375″ = 9.53 mm

This rule does not always apply to dimensions shown as common fractions. A millimeter conversion of a fractional dimension to two decimal places may exaggerate the precision that is required. Therefore, the number of decimal places shown will vary with the accuracy intended.

Example: $\frac{3}{8}$″ may be shown as a conversion to 9.53 mm, 9.5 mm, or 9 mm.

- If a common fraction is to be converted to millimeters and the required degree of accuracy is unknown, an acceptable rule is to show the millimeter equivalent to two decimal places.
- When a metric dimension is less than a full unit, a 0 precedes the decimal point.

Example: 0.39 mm not .39 mm

UNIT 24: REVIEW A

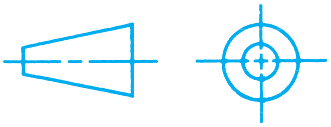
Graph paper is provided at the end of this review for your use.

1. Explain the significance of the following symbols:

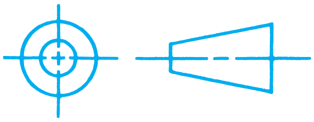
   a. ∅

   b. [ ]

   c.



   d.



2. On dual-dimensioned drawings, is it standard practice to apply dual dimensions to (answer "yes" or "no"):

   a. Welding symbols?

   b. Thread sizes?

   c. Pipe sizes?

   d. Diameters?

   e. Hole sizes?

   f. Cylinders?

   g. Location dimensions?

3. Describe an alternative to dual dimensioning, other than by the positioning or bracket method.

4. Give an advantage of dual-dimensioned drawings.

5. Give a disadvantage of a dual-dimensioned drawing.

6. Show the variations for dual dimensioning by means of the positioning method. Use 6″ and its millimeter equivalent (152.40 mm) to illustrate these variations.

7. Show the variations for dual dimensioning by means of the bracket method. Use 5.750″ and its millimeter equivalent (146.05) to illustrate these variations. Include dimension lines in showing the variations.

8. Fill in the missing dimensions on the following table. Round answers to two decimal places for millimeter conversions and to three decimal places for inch conversion.

Table of Inch/Millimeter Equivalents

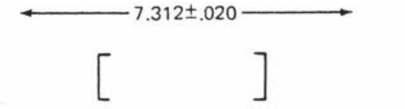
inch	$\frac{3}{16}$		.375		$\frac{1}{2}$		1.250	
mm		7.94		11.11		15.88		2.75

9. Explain the significance of the following note:

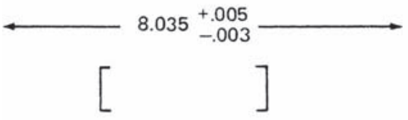
   mm/inch; $\frac{\text{mm}}{\text{inch}}$

10. Add the missing dimensions (in millimeters) to the following dual-dimensioning symbols.

   a.



   b.



11. Show how the following dimensions would be expressed on a dual-dimensioned drawing by means of the positioning method. Use slash lines with U.S. Customary dimensions shown to the left of the slash line, where it is appropriate to do so. Use millimeter equivalent or decimal fraction values where it is appropriate to do so.

   a. 60 - 15′

   b. 12.72″

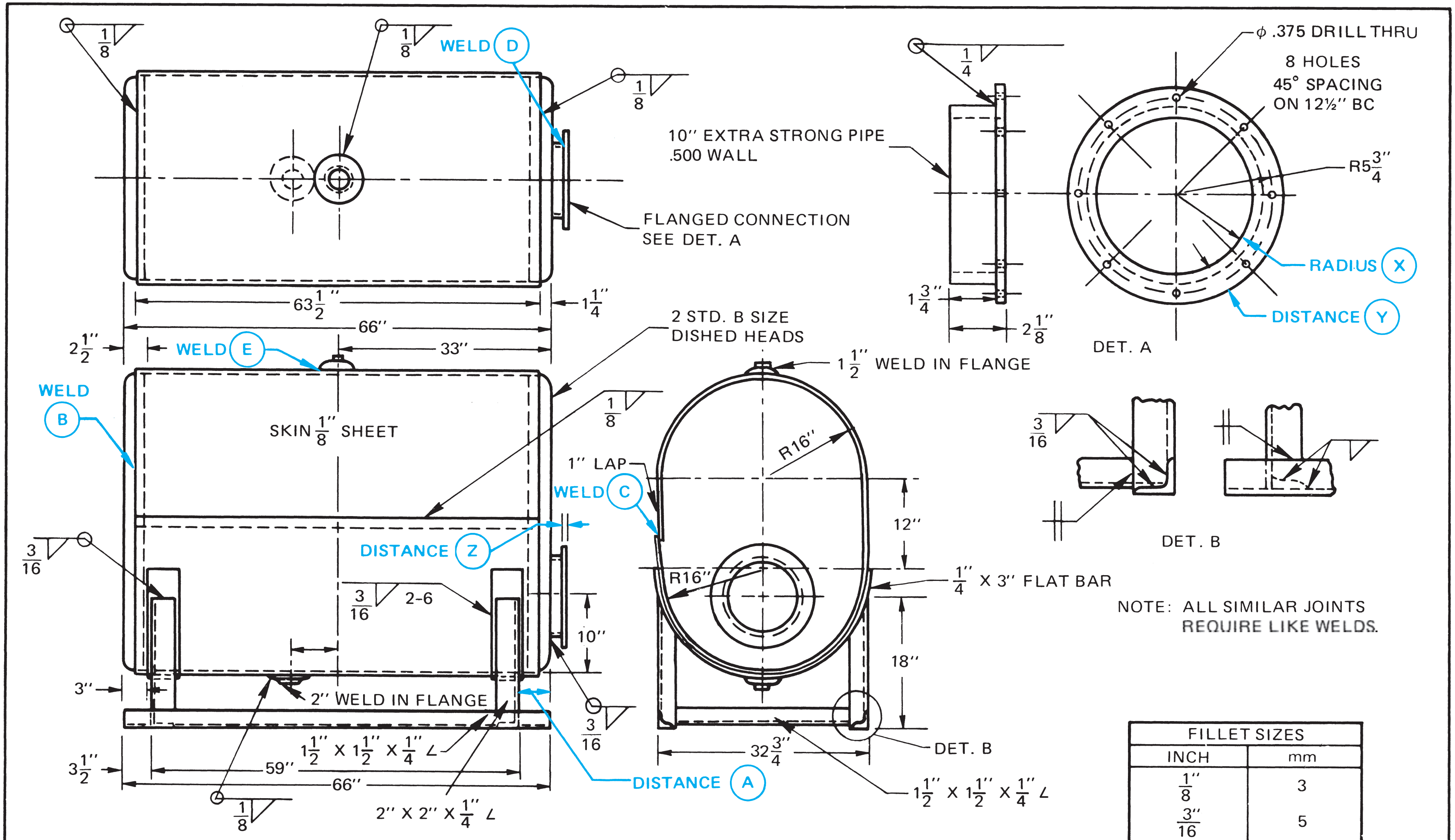
   c. 1¼″ pipe

   d. 254.23 mm

   e. ¼

   f. ¾″ - 12 UNC-2A

NOTES



NOTE: ALL SIMILAR JOINTS REQUIRE LIKE WELDS.

FILLET SIZES	
INCH	mm
1/8"	3
3/16"	5

TABLE OF CONVERSIONS FOR PORTABLE TEST TANK—mm EQUIVALENTS ARE ROUNDED OFF TO ONE DECIMAL PLACE

INCHES	1/8	3/16	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	1 3/4	2	2 1/8	3	3 1/2
MILLIMETERS	3.2	4.8	6.4	9.5	12.7	19.1	25.4	31.8	38.1	44.5	50.8	54.0	76.2	88.9

INCHES	5 3/4	6 1/4	9	10	12	16	16 1/4	18	33	59	63 1/2	66
MILLIMETERS	146.1	158.8	228.6	254.0	304.8	406.4	412.8	457.2	838.2	1498.6	1612.9	1676.4

QTY: 1	ORDER NO. 404
MAT.: AS SPECIFIED	SCALE: 9/16" = 12"
DRAWN BY:	
DWG NO.:	DATE:
PORTABLE TEST TANK	

UNIT 24: REVIEW B

Refer to the drawing, Portable Test Tank, page 293.

1. What information is listed regarding the type of dished heads required?

____

2. What is the type, size, and approximate length of weld Ⓓ?

type _____

size _____ inches _____ mm

approx. length _____ inches _____ mm

3. What type and size welds are used to join the two heads to the skin of the tank?

type _____

size _____ inches _____ mm

4. The total length of 10″ (10.750″OD) (273 mm OD) pipe required is:

_____ inches _____ mm

5. What type and size of weld is used to join the fittings at the top and bottom to the skin of the tank?

type _____

size _____ inch _____ mm

6. The total combined length of ¼ × 3 flat bar required for completion of the tank is:

_____ inches _____ mm

7. If the flange that is welded to the 10″ pipe were cut from a square plate, the minimum outside dimensions of this plate must be:

length _____ inches _____ mm

width _____ inches _____ mm

thickness _____ inch _____ mm

8. The dimensions of the sheet used to form the skin of the tank are:

length _____ inches _____ mm

width _____ inches _____ mm

thickness _____ inch _____ mm

9. The total combined length of 2″ × 2″ × ¼″ angle required will be:

_____ inches _____ mm

10. The total combined length of 1½″ × 1½″ × ¼″ angle required will be:

_____ inches _____ mm

11. The dimension for radius Ⓧ is:

_____ inches _____ mm

12. The dimension for distance Ⓨ is:

_____ inches _____ mm

13. With reference to the bolt circle, the chordal distance between any two of the ⅜″ drilled holes is:

_____ inches _____ mm

14. The approximate total combined length of welds Ⓑ, Ⓒ, and Ⓓ is:

_____ inches _____ mm

15. The overall length of the completed tank, including the flanged connection, will be:

_____ inches _____ mm

16. What is the dimension for distance Ⓐ?

_____ inches _____ mm

17. What is the dimension for distance Ⓩ?

_____ inches _____ mm

18. What views make up the drawing?

____

19. What is the spacing of holes in the flange?

____

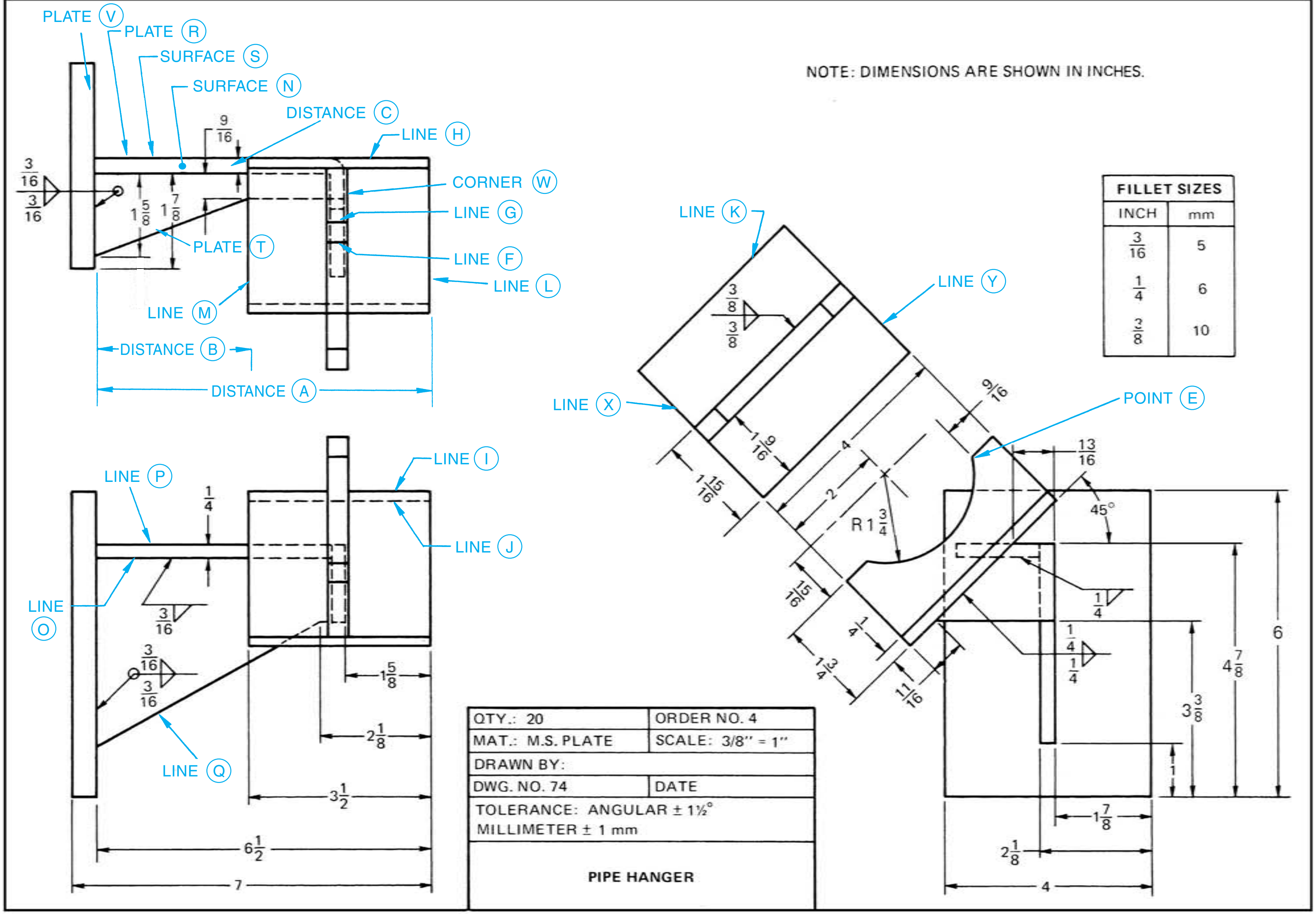
20. Convert 80″ of weld to a mm equivalent.

____

21. Convert 450 mm of weld to an inch equivalent.

____

NOTE: DIMENSIONS ARE SHOWN IN INCHES.



FILLET SIZES

INCH	mm
3/16	5
1/4	6
3/8	10

QTY.: 20	ORDER NO. 4
MAT.: M.S. PLATE	SCALE: 3/8" = 1"
DRAWN BY:	
DWG. NO. 74	DATE
TOLERANCE: ANGULAR ± 1½° MILLIMETER ± 1 mm	
PIPE HANGER	

UNIT 24: REVIEW C

Refer to the drawing, Pipe Hanger, page 295.

1. What is the name of the part?

____

2. What is the order number?

____

3. How many are required?

____

4. How much extra length is allowed for bending the part?

_____ inch _____ mm

5. What are the tolerances on angular dimensions?

____

6. What is the maximum possible overall length?

_____ inches _____ mm

7. What is the minimum possible overall length?

_____ inches _____ mm

8. Point Ⓔ is represented by line _____ in the top view.

9. Line Ⓚ is represented by line _____ in the top view.

10. Surface Ⓝ is represented by line _____ in the front view.

11. Line Ⓜ is represented by line _____ in the auxiliary view.

12. Line Ⓟ represents surface _____ in the top view.

13. What is the dimension of distance Ⓐ?

_____ inches _____ mm

14. What is the dimension of distance Ⓑ?

_____ inches _____ mm

15. What is the dimension of distance Ⓒ?

_____ inches _____ mm

16. a. What type and size of weld is used to join plate Ⓡ to plate Ⓣ?

____

b. Give size of weld in inches.

____

17. a. What type and size of weld is used to join plate Ⓡ to plate Ⓥ?

____

b. Give size of weld in mm. _____ mm

18. a. What type and size of weld is required at corner Ⓦ?

____

b. Give size of weld in inches and mm.

_____ inches _____ mm

19. Where are the welds that join plates Ⓡ and Ⓣ to the plate Ⓥ to be made?

____

20. a. How many mm of fillet welds will be required for completion of the order?

____

b. How many inches?

____

21. a. Explain why it was desirable to include an auxiliary view on this drawing.

____

b. At what angle is it drawn?

____

22. How many angular dimensions are shown?

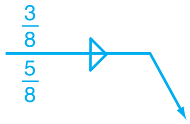
____

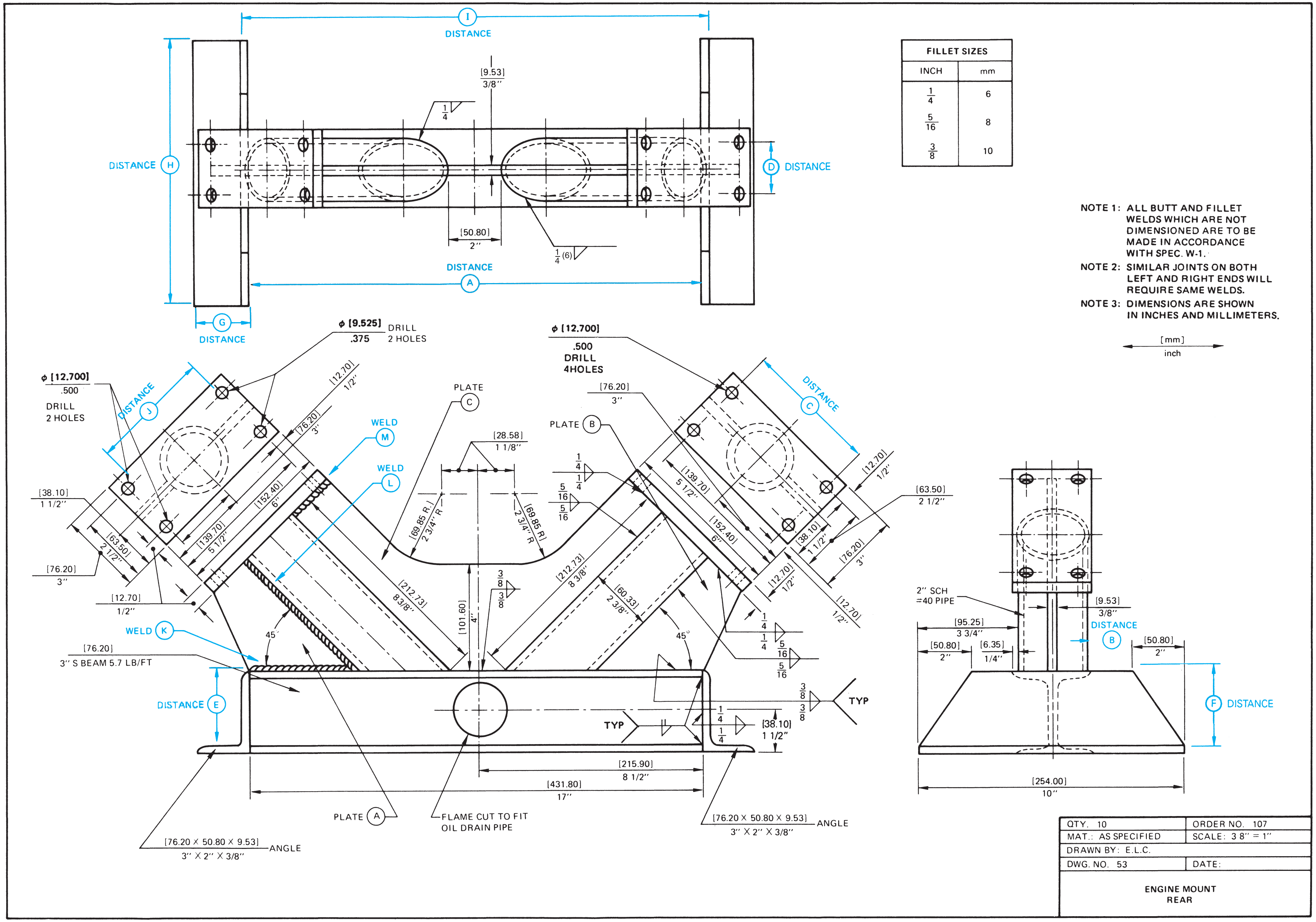
23. Make a complete bill of materials required for completion of the order. NOTE: Allow enough material for the cutting of all irregular-shaped plates. List the dimensions in inches and in mm.

Bill of Materials

No.	Material	Size

24. Apply dual dimensioning to the following welding symbol.





FILLET SIZES

INCH	mm
1/4	6
5/16	8
3/8	10

NOTE 1: ALL BUTT AND FILLET WELDS WHICH ARE NOT DIMENSIONED ARE TO BE MADE IN ACCORDANCE WITH SPEC. W-1.

NOTE 2: SIMILAR JOINTS ON BOTH LEFT AND RIGHT ENDS WILL REQUIRE SAME WELDS.

NOTE 3: DIMENSIONS ARE SHOWN IN INCHES AND MILLIMETERS.

QTY. 10	ORDER NO. 107
MAT.: AS SPECIFIED	SCALE: 3 8″ = 1″
DRAWN BY: E.L.C.	
DWG. NO. 53	DATE:
ENGINE MOUNT REAR	

EDITOR'S NOTE: REDUCED PRINT, FOLLOW STATED DIMENSIONS ONLY. NOT TO BE SCALED.
A LARGER DRAWING IS PROVIDED AT THE BACK OF THE TEXT.

UNIT 24: REVIEW D

Refer to the drawing, Engine Mount Rear, page 297.

1. What is the name of the part?

   ____

2. How many are required to complete the order?

   ____

3. What is the order number?

   ____

4. What scale is used for the drawing?

   ____

5. What is the dimension of distance Ⓗ?

   _____ inches _____ mm

6. What is the dimension of distance Ⓘ?

   _____ mm

7. What is the dimension of distance Ⓖ?

   _____ mm

8. What is the dimension of distance Ⓐ?

   _____ inches _____ mm

9. What is the dimension of distance Ⓓ?

   _____ mm

10. What is the dimension of distance Ⓙ?

    _____ mm

11. What is the dimension of distance Ⓒ?

    _____ inches _____ mm

12. What is the dimension of distance Ⓔ?

    _____ mm

13. What is the dimension of distance Ⓑ?

    _____ inches _____ mm

14. What is the dimension of distance Ⓕ?

    _____ mm

15. How many flame-cut holes will there be in the completed order?

    ____

16. Identify the member that will be inserted in the flame-cut hole.

    ____

17. How many ∅ .375 drilled holes will there be in the completed order?

    ____

18. How many ∅ .500 drilled holes will there be in the completed order?

    ____

19. a. At what angle will the ends of the pipe be cut where it joins the I beam?

    ____

    b. What is the size of this pipe?

    ____

20. What type and size is weld Ⓚ? ____________
    Ⓛ? ____________ Ⓜ? ____________

21. How many welding symbols are shown?

    ____

22. How many ¼″ fillet welding symbols are shown?

    ____

23. How many ⅜″ fillet welding symbols are shown?

    ____

24. What types of welds are used to join the angle to the S beam?

    ____

25. a. What information is given regarding welds that are not dimensioned?

    ____

    b. Make a complete bill of materials that will be required for completion of the order (omit plates A, B, and C). Give dimensions in inches and millimeters.

Bill of Materials

No.	Material	Size

26. Sketch the weld symbol that is dual dimensioned.

    ____

UNIT 25

Inspection and Testing

OVERVIEW OF COMMON INSPECTION AND TESTING PRACTICES

The primary aim of any inspection or testing program is to ensure that governing codes, standards, and specifications are followed, and that weld quality meets design standards. In addition, the weld must satisfy the operating conditions to which the weldment will be subjected. To meet these goals, the welder is often required to complete performance qualification tests. These tests are designed to determine the welder's ability to deposit consistently sound, high-quality welds as required by the codes under which the weldment is being completed. The code-writing organizations that dictate these standards include the following:

American Welding Society (AWS)
Canadian Standard Association (CSA)
American Society of Mechanical Engineers (ASME)
American Society for Testing Materials (ASTM)
American Petroleum Institute (API)
American Bureau of Shipping (ABS)

Inspection and testing practices used by these organizations are divided into two basic categories: destructive testing and nondestructive examination.

DESTRUCTIVE TESTING

Destructive testing involves subjecting weld specimens to a series of mechanical tests that measure various metallurgical properties. These tests ensure that the welding process has been performed properly, that the joint design was correct, and that the proper filler metal was selected. Tests of this nature may make the specimen unfit for further service. In certain cases where sample weld sections are removed from a unit for testing, the specimen may be repaired or rewelded to restore it to its original condition.

Destructive tests may also be used to certify a welder's ability to produce sound, high-quality welds. The following list identifies the various destructive tests and the metallurgical properties each measures.

Bend testing—to determine ductility and soundness
Tensile testing—to determine tensile strength and ductility
Nick break test—to determine structure and soundness
Impact test—to determine impact strength
Hardness test—to determine hardness
Macro etch test—to determine the depth of weld metal penetration, fusion zone, and heat-affected zone

NONDESTRUCTIVE EXAMINATION

Nondestructive examination practices are used to evaluate weld quality without permanent damage to the weldment. Some of these practices may be used (1) as preparations for the welding operation, (2) as the weld progresses, and (3) after the weld is complete. The following nondestructive practices are described: visual inspection, ultrasonic inspection, radiographic test, magnetic particle inspection, dye penetrant test, eddy current (electromagnetic) test, leak test, and proof tests.

Visual Examination

Visual examination is one of the most extensively used inspection practices for the following reasons:

- it is easy to perform,
- it is used by all workers who are associated with welding practices, and
- it is relatively inexpensive.

Visual examination reveals the presence of base metal conditions such as mill scale, seams, laminations, and other surface conditions that could contribute to faulty welds. As preparations for welding are being made, visual examination detects incorrect groove angle, root face, and root opening. Visual examination also determines the general uniformity of fitup. As welding progresses, visual examination detects conditions that could result in a faulty weld upon completion. An example of such a condition is inadequate cleaning between passes. This method of inspection is widely used upon completion of the weld and the weldment for the following reasons:

- to determine the dimensional accuracy of the weldment, and
- to check general conformity to specifications, including weld dimensions and the general acceptability of the welds, including conditions such as rough or irregular deposits; the existence of spatter; arc strike marks; the presence of unfilled craters; overlap; undercut; and weld and base metal cracks.

Ultrasonic Examination

In this method of examination, ultra-high-frequency sound waves are transmitted through the part being tested. These sound waves are then reflected back from the opposite side of the material and are displayed on an oscilloscope screen. Defects in the material or weld cause variations in the echo, and the result is displayed on the oscilloscope, showing the extent and location of the defect. This inspection method may be used on most materials. However, a high degree of operator skill is required to interpret the oscilloscope screen images accurately. This is called straight beam testing, which is not frequently used on welds. Most weld inspection uses angle beam testing, which shows reflections from defects.

Radiographic Examination

The radiographic method makes use of the ability of X rays or gamma rays to penetrate objects. When these rays are directed through a welded joint, a portion of the radiation is absorbed. The amount absorbed depends upon the thickness and density of the weld. If defects exist in the weld, the beam of radiation will have less metal to pass through than if the weld were completely sound. These variations in radiation penetration are recorded on a photographic film in the form of light or dark images that indicate the location, shape, and size of any existing defect (in two dimensions only).

Magnetic Particle Examination

This method requires that a magnetic field be established in the part being inspected. A high current is used to set up this magnetic field. If any discontinuities exist, such as surface or subsurface cracks or laminations, the magnetic field is distorted. The surface of the area being inspected is covered with fine ferromagnetic particles. These particles tend to gather at the area of the imperfection. They indicate not only the location of the fault but also the shape and extent of the fault. Since this method depends on the establishment of magnetic fields, it cannot be used with most nonferrous metals or austenitic steels. However, it has been used with nickel alloys.

Penetration Examination

In this method of examination, a dye penetrant is applied to the surface being examined. The dye is allowed to stand for a period of time, the excess is removed using cleaning agents, and a developer is applied to the surface.

When the developer dries, a white background remains that draws the penetrant trapped in the flaw or fault to the surface to highlight the location of the fault. Another method makes use of a fluorescent penetrant, which is absorbed into the flaw. Ultraviolet light is then applied to the area under examination, thus revealing any flaw.

Eddy Current (Electromagnetic) Examination

In this method, the parts being tested are subjected to the influence of an alternating electromagnetic field, which will induce eddy currents. If the material conducts electricity, magnetic fields will be set up. This method is adaptable to the testing of items on a relatively high-speed production basis. It is useful for the detection of both surface faults and faults just below the surface such as cracks, voids, or laminations. This method is widely used where welded surfaces are smooth, such as in the aircraft industry. It is considered ineffective for the inspection of rough surfaces often present on weldments.

Leak Examination

The most common method of examination is one of the simplest. It is also the most economical method of testing welds on vessels and piping systems. It involves simply filling the vessel with water and examining the outside of it for evidence of leaks. (This is known as hydrostatic testing.) Light oils may also be used in some cases. The oil tends to make small leaks more easily detectable. Another common practice is to increase the internal pressure of the vessel to greater than atmospheric pressure. The exterior of the vessel is then examined for evidence of leaks. When air or nonflammable gas under pressure is used for this purpose, a soapy solution is often applied to the weld on the exterior of the vessel. Any leaks cause bubbles to be formed. For small vessels, it is sometimes possible to submerge the vessel completely in water. It can then be examined for evidence of rising bubbles, indicating leaking welds.

Proof Examination

This method of examination is used to determine if the weldment is capable of performing the service for which it was designed. This examination usually involves the application of service loading greater than that to which the weldment would normally be exposed. Closed containers or piping systems are subjected to internal pressure by applying air (pneumatic) or water (hydrostatic) pressure.

NONDESTRUCTIVE EXAMINATION SYMBOLS

Nondestructive testing symbols are used to indicate the type of test or tests the welds will be subjected to when completed. Abbreviations for the common examinations are shown in Table 25.1.

The examination symbol consists of a reference line, arrow, and tail. Elements added to this symbol are examination symbols, basic weld symbols, the examine-all-around symbol (similar to the weld-all-around symbol), the examine-in-field symbol (similar to the field-weld symbol), number of tests, length or percentage of the part to be examined, specifications or references, and direction of radiation for radiographic tests, Figure 25.1. The arrow side, other side, and both sides significance described for the basic welding symbol also applies to the nondestructive testing symbol.

As indicated in Figure 25.1, examination symbols may be applied in three locations with respect to the reference line of the nondestructive welding symbol—on the arrow side, on the other side, or centered on the reference line. When a both sides significance is desired, the examination symbol

Type of Test	Symbol
Acoustical test	AET
Electromagnetic	ET
Leak	LT
Magnetic particle	MT
Neutron radiographic	NRT
Penetrant	PT
Proof	PRT
Radiographic	RT
Ultrasonic	UT
Visual	VT

TABLE 25.1 ■ Nondestructive examination symbols. *Note*: Each symbol ends with the letter "T."

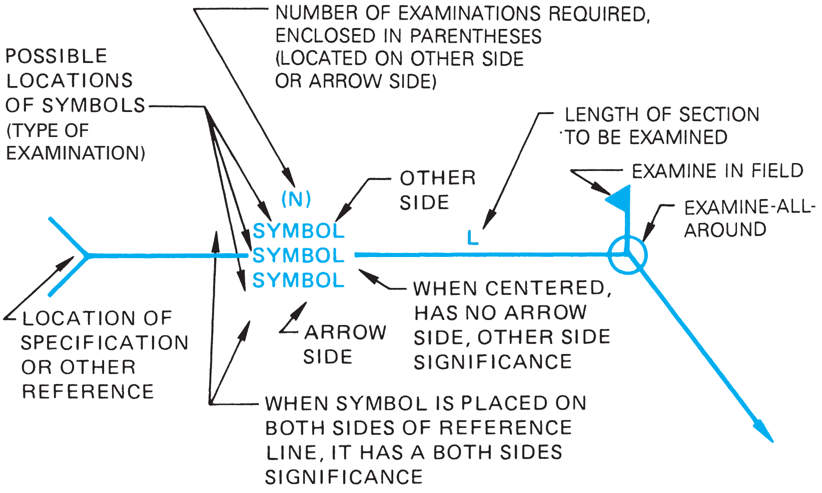

NUMBER OF EXAMINATIONS REQUIRED, ENCLOSED IN PARENTHESES (LOCATED ON OTHER SIDE OR ARROW SIDE)
POSSIBLE LOCATIONS OF SYMBOLS (TYPE OF EXAMINATION)
LENGTH OF SECTION TO BE EXAMINED
EXAMINE IN FIELD
OTHER SIDE
EXAMINE-ALL-AROUND
(N)
SYMBOL
SYMBOL
SYMBOL
L
WHEN CENTERED, HAS NO ARROW SIDE, OTHER SIDE SIGNIFICANCE
LOCATION OF SPECIFICATION OR OTHER REFERENCE
ARROW SIDE
WHEN SYMBOL IS PLACED ON BOTH SIDES OF REFERENCE LINE, IT HAS A BOTH SIDES SIGNIFICANCE

FIGURE 25.1 ■ Nondestructive examination symbol.

is applied to both sides of the reference line. When an arrow side or other side significance is not applicable, the examination symbol is centered on the reference line, Figure 25.2.

When multiple tests are required, they are indicated by combining the test symbols, as shown in Figure 25.3. Note that test symbols having an arrow side or other side significance may be combined with a test symbol centered on the reference line (no arrow side or other side significance).

Test symbols are frequently used in combination with basic weld symbols. When this is the case, they are applied to a testing symbol with multiple reference lines, Figure 25.4.

For testing purposes, the dimensions applied to a testing symbol are: (1) length of section to be tested, or (2) percentage of section to be tested, and (3) angle of radiation when a radiographic test is required. Length or percentage is shown *only* when a partial section is to be tested. Note that when length or percentage dimensions are used, they are located to the right of the test symbol, Figure 25.5 and Figure 25.6.

Dimensions may also be added as shown in Figure 25.7 to locate the particular length of weld to be tested.

When a percentage dimension is used to indicate that only a partial section of the weld is to be tested, the procedure for selecting the location of the test is described in the specifications or by a note on the drawing, Figure 25.8.

In cases where testing applies to an **area** of a part, several dimensioning techniques are used. For a **plane area**, the section of the area to be examined is shown circumscribed

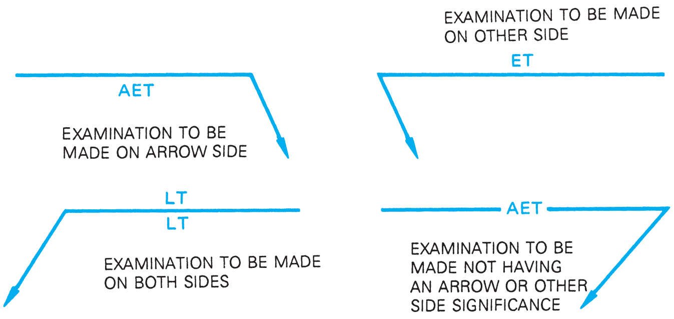

EXAMINATION TO BE MADE ON OTHER SIDE
ET
AET
EXAMINATION TO BE MADE ON ARROW SIDE
LT
LT
EXAMINATION TO BE MADE ON BOTH SIDES
AET
EXAMINATION TO BE MADE NOT HAVING AN ARROW OR OTHER SIDE SIGNIFICANCE

FIGURE 25.2 ■ Locations of test symbols.

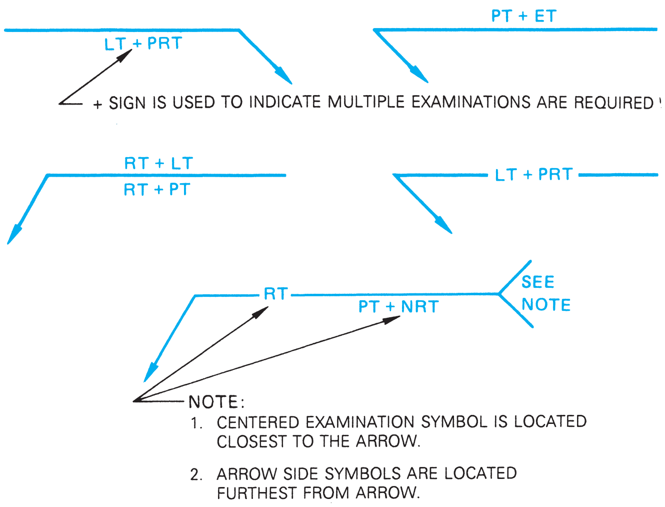
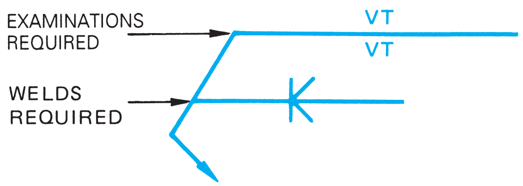

PT + ET
LT + PRT
+ SIGN IS USED TO INDICATE MULTIPLE EXAMINATIONS ARE REQUIRED
RT + LT
RT + PT
LT + PRT
RT
PT + NRT
SEE NOTE
NOTE:
1. CENTERED EXAMINATION SYMBOL IS LOCATED CLOSEST TO THE ARROW.
2. ARROW SIDE SYMBOLS ARE LOCATED FURTHEST FROM ARROW.

FIGURE 25.3 ■ Combining examination symbols.



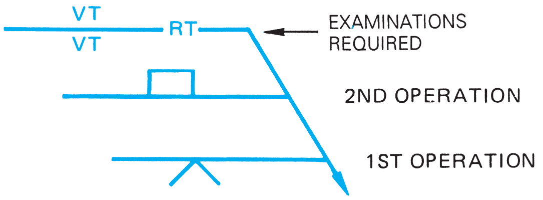


FIGURE 25.4 ■ Combining basic weld and nondestructive examination symbols through the use of multiple reference lines.

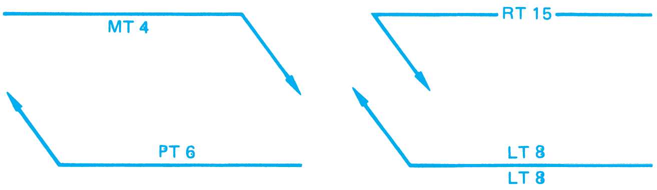


FIGURE 25.5 ■ Application of length dimension for examining a partial section.

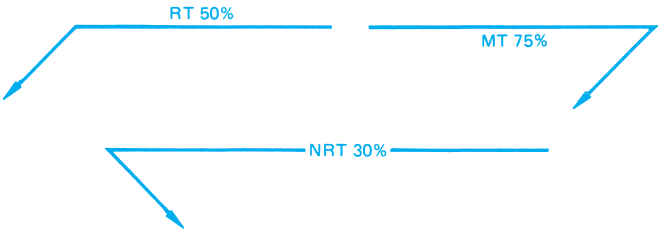


FIGURE 25.6 ■ Application of percentage dimension for examining a partial section of weld.

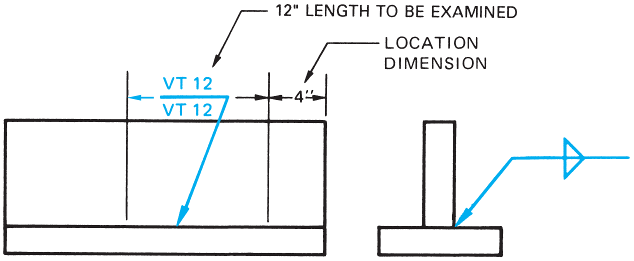


FIGURE 25.7 ■ Application of dimensions for indicating length of welded section to be examined.

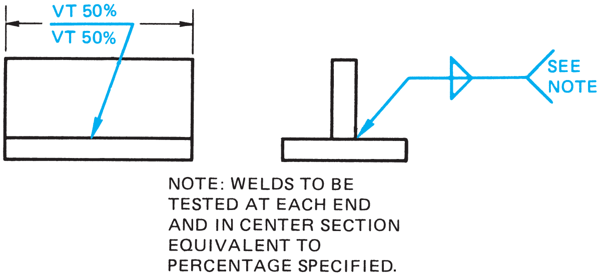

VT 50%
VT 50%
SEE NOTE
NOTE: WELDS TO BE TESTED AT EACH END AND IN CENTER SECTION EQUIVALENT TO PERCENTAGE SPECIFIED.

FIGURE 25.8 ■ Percentage method of indicating extent of a welded section to be examined.

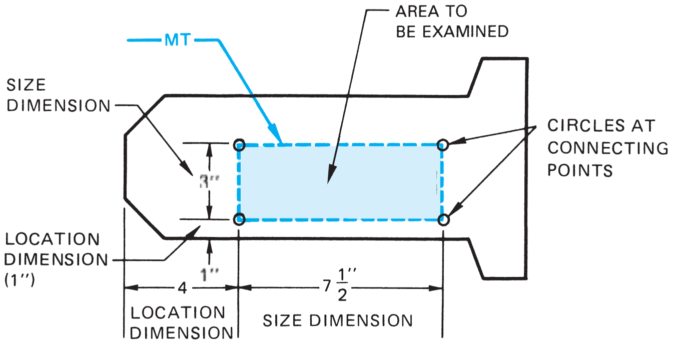


FIGURE 25.9 ■ Method of indicating a section of a plane area to be examined.

by broken lines with circles at the connecting points, Figure 25.9. Location and size dimensions are applied as needed. The appropriate examination symbol is added with the arrow touching any point of the perimeter of the area to be examined, Figure 25.9.

To indicate that an **area of revolution** is to be examined, the examine-all-around symbol is applied, with or without a length dimension, depending upon the extent of the area to be examined, Figure 25.10.

When a length dimension is applied to the testing symbol with an examine-all-around symbol, it signifies that only a particular length of the area of revolution is to be examined, Figure 25.11.

For pressure vessels or pipe, an acoustic emission examination may be indicated, Figure 25.12. When such an examination is indicated, it generally applies to all or most of the component. Therefore, no dimension is shown with the symbol. The locations of the sensors for making the examination are not shown. This permits a random selection of locations for making the examination.

For radiographic inspections, the degree of angle for executing the inspection is included on the drawing, Figure 25.13(a). The angle dimension is applied between an extension line and an extension of the arrow of the welding symbol resembling an asterisk is located at the end of the arrow extension line. When an angle dimension is not shown, it implies that the angle of radiation is 90°, Figure 25.13(b).

The remaining element applied to the nondestructive examination symbol is the number of examinations to be made. This is indicated by placing a numerical value in parentheses above or below the examination symbol, Figure 25.14. When the examination symbol is located on the arrow side, the figure is placed below the symbol; when the examination symbol is on the other side, it is placed above the examination symbol. If the symbol is centered on the reference line, the indication for the number of examinations is placed on either

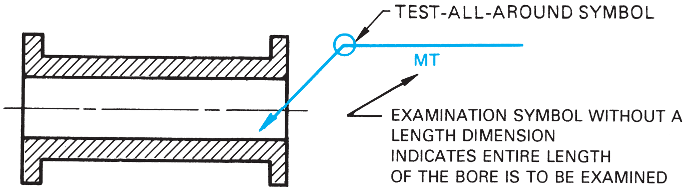

TEST-ALL-AROUND SYMBOL
MT
EXAMINATION SYMBOL WITHOUT A LENGTH DIMENSION INDICATES ENTIRE LENGTH OF THE BORE IS TO BE EXAMINED

FIGURE 25.10 ■ Application of the examine-all-around symbol for an area of revolution to be examined.

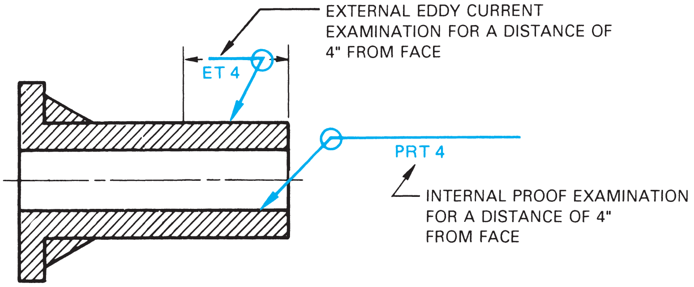

EXTERNAL EDDY CURRENT EXAMINATION FOR A DISTANCE OF 4" FROM FACE
ET 4
PRT 4
INTERNAL PROOF EXAMINATION FOR A DISTANCE OF 4" FROM FACE

FIGURE 25.11 ■ Application of examination-all-around symbol and length dimension for an area of revolution.

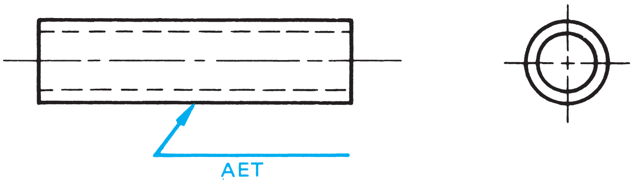


FIGURE 25.12 ■ Application of accoustic emission examination symbol for testing a length of pipe.

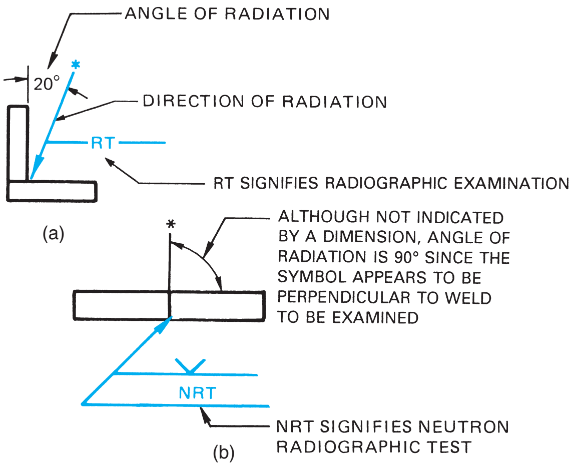

ANGLE OF RADIATION
20°
*
DIRECTION OF RADIATION
RT
RT SIGNIFIES RADIOGRAPHIC EXAMINATION
(a)
*
ALTHOUGH NOT INDICATED BY A DIMENSION, ANGLE OF RADIATION IS 90° SINCE THE SYMBOL APPEARS TO BE PERPENDICULAR TO WELD TO BE EXAMINED
NRT
NRT SIGNIFIES NEUTRON RADIOGRAPHIC TEST
(b)

FIGURE 25.13 ■ Application of direction of radiation dimension for radiographic examinations.

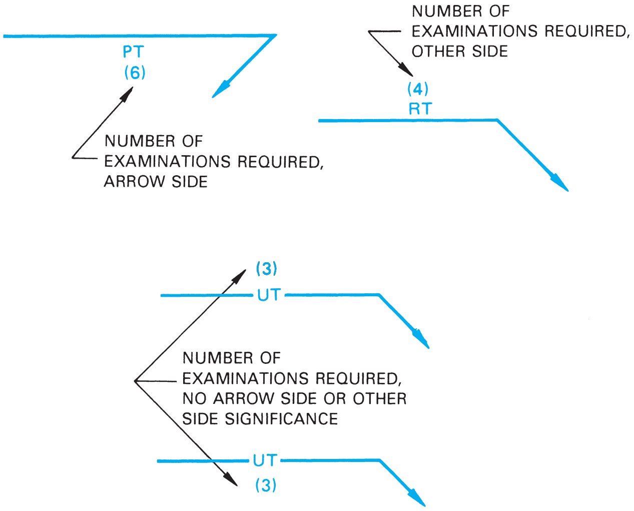

PT
(6)
NUMBER OF EXAMINATIONS REQUIRED, ARROW SIDE
NUMBER OF EXAMINATIONS REQUIRED, OTHER SIDE
(4)
RT
(3)
UT
NUMBER OF EXAMINATIONS REQUIRED, NO ARROW SIDE OR OTHER SIDE SIGNIFICANCE
UT
(3)

FIGURE 25.14 ■ Application of figure to examination symbol to indicate the number of tests required.

side of the symbol. In determining locations for the examination, they are taken at random along the joint or area of the part to which the symbol is applied.

Dimensioning practices applied to the nondestructive examination symbol exclude dual dimensioning (the use of both U.S. Customary and metric dimensions). When dimensions in both units are necessary, a table of conversions is added to the drawing. Examples of conversion tables are shown in Table 25.2 and may also be found in the Appendices.

Electrode Sizes		**Fillet Sizes**	
in.	**mm**	**in.**	**mm**
0.030	0.76	1/8	3
0.035	0.89	5/32	4
0.040	1.02	3/16	5
0.045	1.14	1/4	6
1/16	1.59	5/16	8
5/64	1.98	3/8	10
3/32	2.38	7/16	11
1/8	3.18	1/2	13
5/32	3.97	5/8	16
3/16	4.76	3/4	19
1/4	6.35	7/8	22
		1	25

U.S. Customary (Inch)

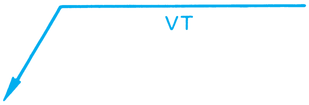
Metric (Millimeters)

TABLE 25.2 ■ Conversion tables.

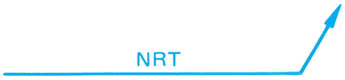
UNIT 25: REVIEW

1. Describe nondestructive examinations and their locations indicated by the following symbols.

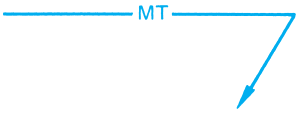
a.



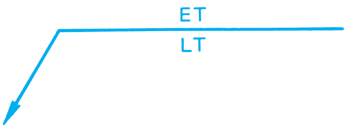
b.



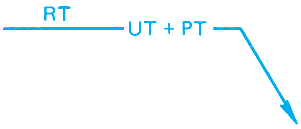
c.



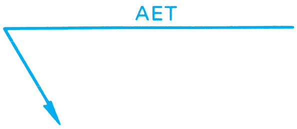
d.



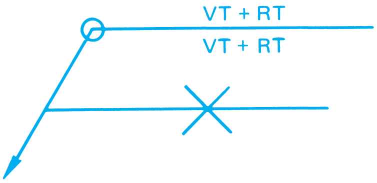
e.



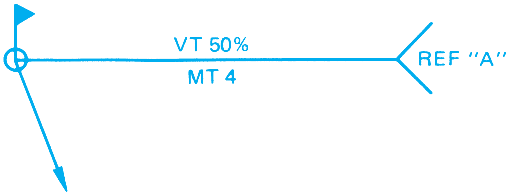
f.



g.



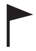
2. Give the significance of each element shown on the following nondestructive examination symbol.

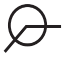


VT 50%

MT 4

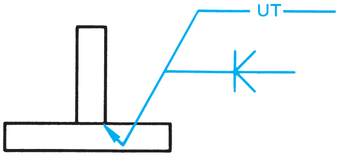
REF "A"

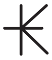




3. Give the significance of all of the elements applied to the examination symbols shown on the drawings that follow.

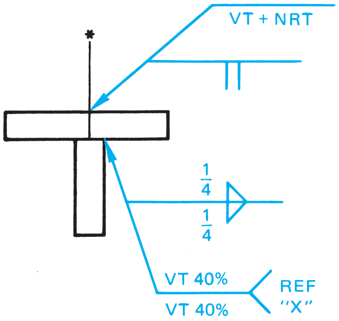
a.



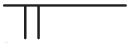


UT

b.



VT + NRT ____________________



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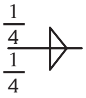

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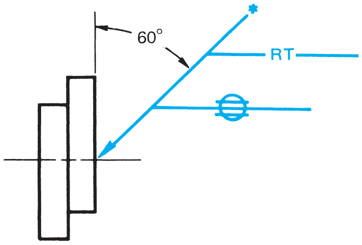
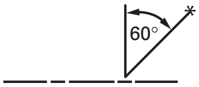
VT 40%
VT 40% ____________________

REF "X" ____________________

c.



RT ____________________



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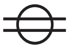
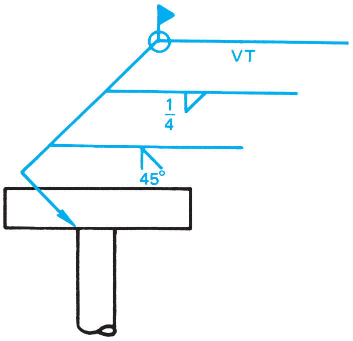
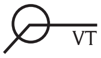


____

d.





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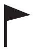

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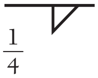

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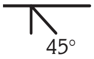

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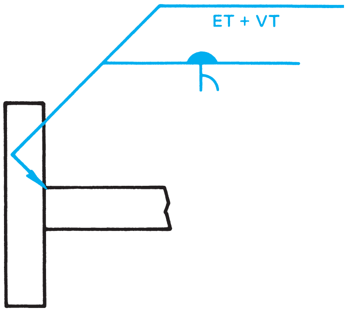
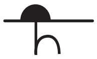
e.



ET + VT ____________________

____



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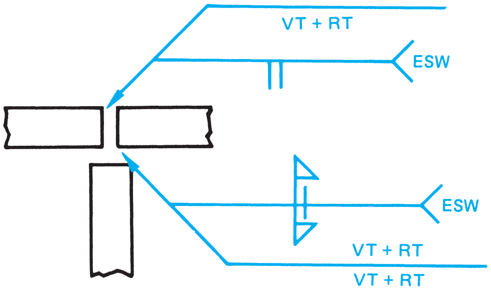
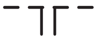
f.



VT + RT ____________________



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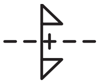

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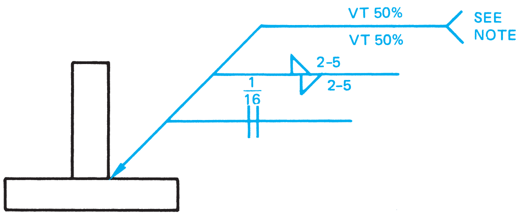
ESW ____________________

VT + RT
VT + RT ____________________

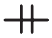
____

g.



VT 50%
VT 50% ______________________________

$\frac{1}{16}$ ______________________________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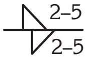

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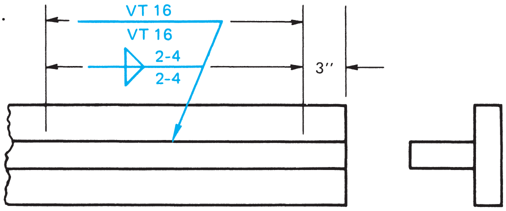
SEE NOTE ______________________________

h.



VT 16
VT 16 ______________________________

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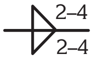

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3″ ______________________________

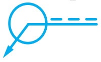
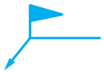
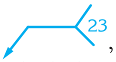
UNIT 26

International Standard Symbols for Welding

INTRODUCTION TO ISO SYMBOLOGY

In addition to American Welding Society (AWS) weld symbols, a set of weld symbols has been developed for international use, identified as "International Standard Symbols for Welding." These symbols (often referred to as ISO symbols) have been approved by the International Organization of Standardization and are found in the publication *International Standard 2553*. They are intended for application on drawings used for the manufacture of products marketed internationally.

International weld symbols fall into two principal categories: (1) elementary and (2) supplementary. They are illustrated in Table 26.1 and Table 26.2. In reviewing Table 26.1, note that there are two symbols unique to ISO: the single-V butt weld with broad root face, and the single-bevel butt weld with broad root face. Note also that there are variations in the descriptions of several of the weld symbols when compared to AWS descriptions of similar symbols. Each elementary symbol represents the shape of the weld to be made and, similarly, each supplementary symbol is indicative of the shape of the weld surface required.

In addition to elementary and supplementary symbols, ISO includes a classification of symbols entitled "Complementary Indications." These consist of the (1) peripheral weld,  (2) field or site weld,  and (3) the welding process , which is represented by a number included in the tail (also identified by AWS as the "tail"). The number in the tail corresponds to a welding process found in ISO publication *4063*. Note that the tail is applied to the symbol only when a welding process is to be indicated.

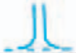
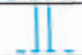
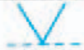
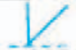
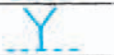
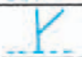
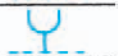
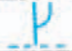
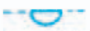
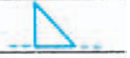
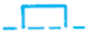
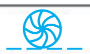
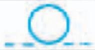
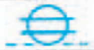
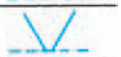
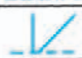
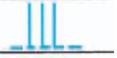
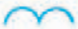
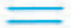
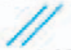
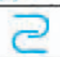
No.	Designation	Symbol
1	Butt weld between plates with raised edges[1]	
2	Square butt weld	
3	Single-V butt weld	
4	Single-bevel butt weld	
5	Single-V butt weld with broad root face	
6	Single-bevel butt weld with broad root face	
7	Single-U butt weld (parallel or sloping sides)	
8	Single-J butt weld	
9	Backing run; back or backing weld/USA/	
10	Fillet weld	
11	Slot weld	
12	Plug weld	
13	Spot weld	
14	Seam weld	
15	Steep-flanked single-V butt weld	
16	Steep-flanked single-bevel butt weld	
17	Edge weld	
18	Surfacing weld	
19	Surface joint	
20	Inclined joint	
21	Fold joint	

TABLE 26.1 ■ Elementary symbols.

Note: Dashed lines are not a part of the symbol.

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[1] Butt welds between plates with raised edges (symbol 1) not completely penetrated are symbolized as square butt welds (symbol 2) with the weld thickness shown.

Shape of Weld Surface	Symbol
Flat (usually finished flush)	—
Convex	⌒
Concave	◡
Toes shall be blended smoothly	⚓
Permanent backing strip used	M
Removable backing strip used	MR

TABLE 26.2 ■ Supplementary symbols.

ELEMENTS OF AN ISO SYMBOL

An ISO symbol used to represent a weld requirement consists of an arrow line, a multiple reference line, and the appropriate welding symbol or symbols, Figure 26.1.

The method for representing a symbol with the use of a multiple reference line is illustrated in Figure 26.2. For symmetrical welds, a single continuous reference line is used. In such cases, the dashed line is unnecessary, Figure 26.3.

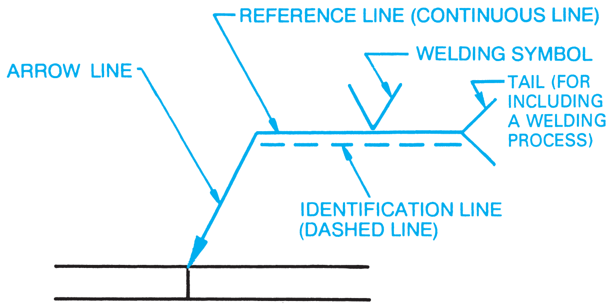

REFERENCE LINE (CONTINUOUS LINE)
WELDING SYMBOL
ARROW LINE
TAIL (FOR INCLUDING A WELDING PROCESS)
IDENTIFICATION LINE (DASHED LINE)

FIGURE 26.1 ■ Components of an ISO symbol for representing a weld requirement.

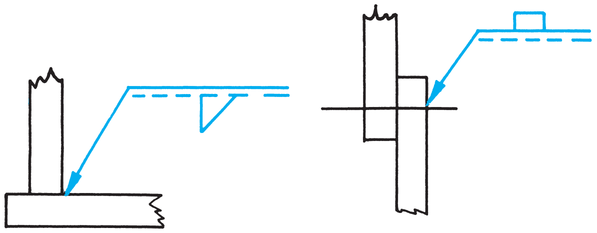


FIGURE 26.2 ■ Method of representing an ISO symbol for a weld that requires a dual reference line (solid and dashed).

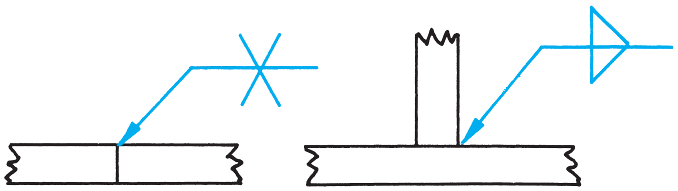


FIGURE 26.3 ■ Method of representing an ISO symbol for symmetrical welds (when only a continuous single reference line is applied).

The purpose of a dual reference line is to be able to readily identify to which side of a joint the welding symbol applies. When applied to the dashed line, it signifies the other side of the joint; when applied to the continuous reference line, it signifies the arrow side of the joint. The dashed line may be drawn above or below the continuous line and is parallel to the continuous line, Figure 26.4.

In Figure 26.1, note that a tail is not included as an integral part of the symbol, and there is no term used to identify the total symbol (in the case of AWS symbology, it is identified as a "welding symbol"). In addition, whereas AWS basic symbols are identified as weld symbols, ISO identifies its comparable elementary symbols as welding symbols. A comparison of ISO and AWS symbols is illustrated in Table 26.9.

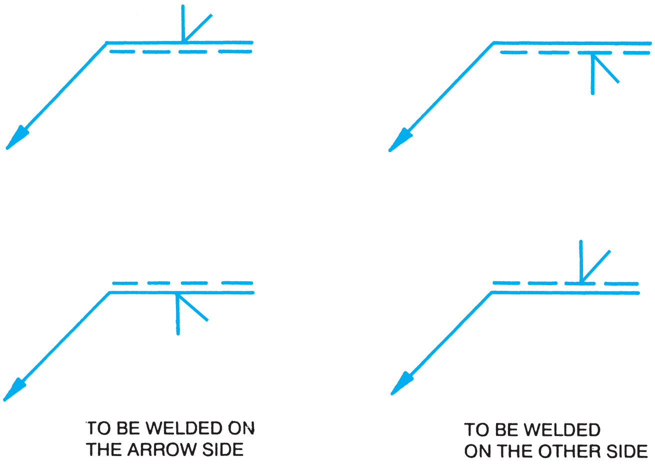


FIGURE 26.4 ■ Interpretation of multiple reference lines.

Arrow Side, Other Side Significance

The arrow side, other side significance of a joint is the same for an ISO symbol and an AWS symbol. Examples are illustrated in Figure 26.5.

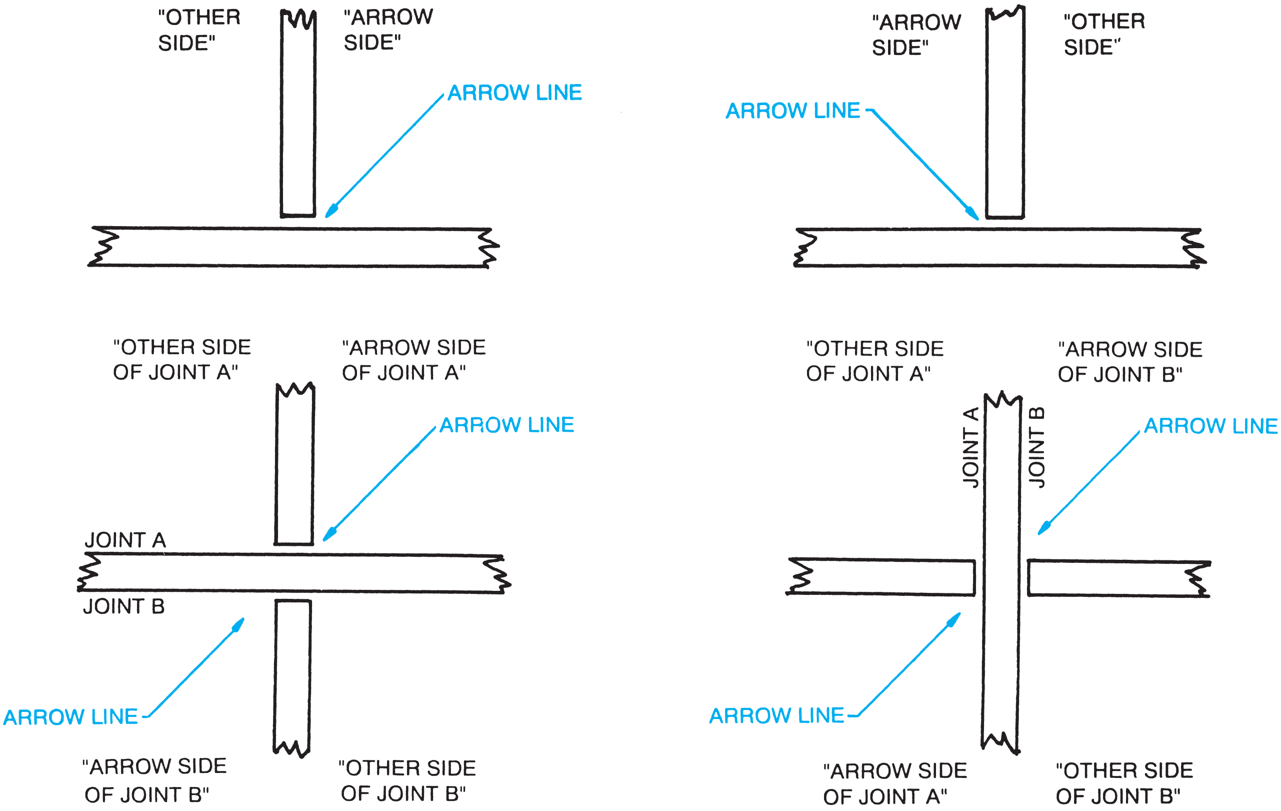


FIGURE 26.5 ■ Identification of arrow side and other side of joint members for ISO standards.

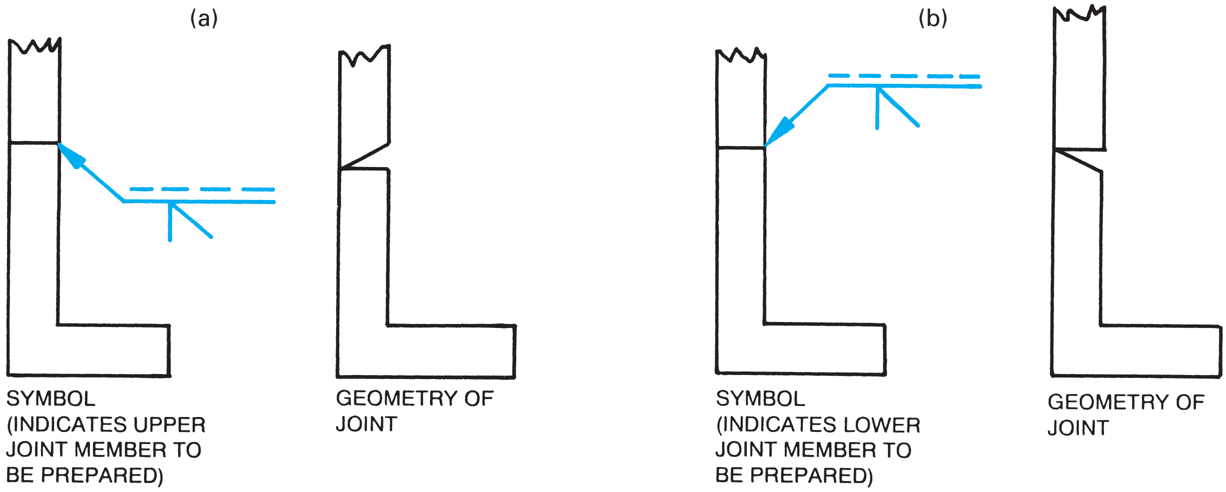

(a)
SYMBOL (INDICATES UPPER JOINT MEMBER TO BE PREPARED)
GEOMETRY OF JOINT
(b)
SYMBOL (INDICATES LOWER JOINT MEMBER TO BE PREPARED)
GEOMETRY OF JOINT

FIGURE 26.6(a, b) ■ Method for indicating which member of a joint is to be prepared.

Method for Indicating Which Member of a Joint Is to Be Prepared

An ISO symbol does not provide for the use of a broken arrow line to indicate which joint member of a groove weld is to be prepared. However, it is indicated by an unbroken arrow line as illustrated in Figure 26.6. When the direction of the arrow points toward the upper member of the joint, it indicates that the upper member is to be prepared, Figure 26.6(a). Conversely, when it points toward the lower member, it indicates that the lower member is to be prepared, Figure 26.6(b).

DIMENSIONS APPLIED TO ISO SYMBOLS

The variety of dimensions applied to ISO symbols and their locations with respect to the symbols are similar to AWS welding symbols. However, there are a number of differences, as will be found in an analysis of Table 26.3.

Examples of the use of ISO symbols are illustrated in Table 26.4 through Table 26.8. For purposes of clarity, dimensions have not been applied to these symbols.

A comparison of ISO symbols to AWS welding symbols is found in Table 26.9. Additional symbols applicable to AWS and not found in ISO symbology are illustrated in Table 26.10.

Examples of Use of Symbols

Table 26.4 through Table 26.8 give selected examples of the use of ISO symbols. They are given for explanation purposes only.

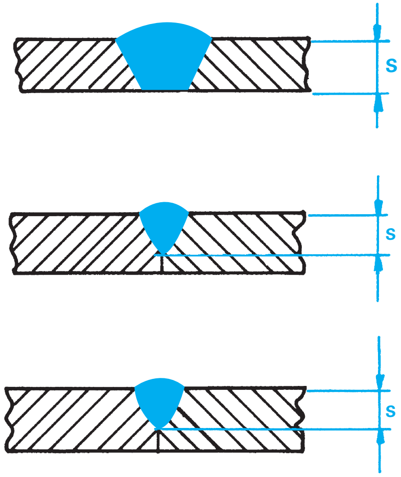
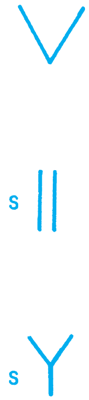
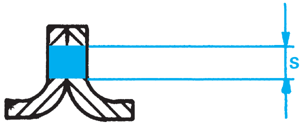
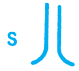
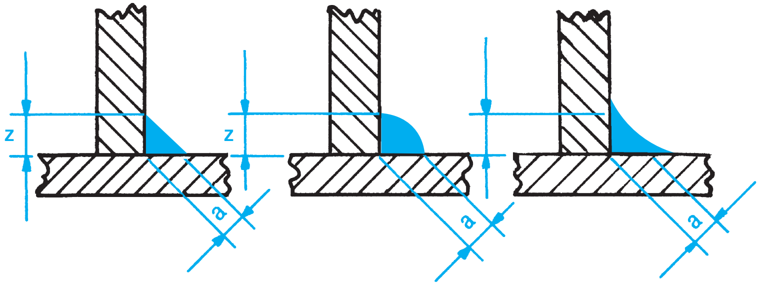
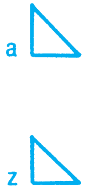
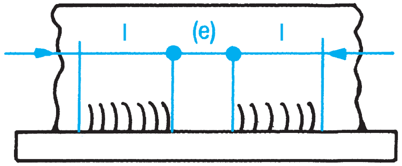
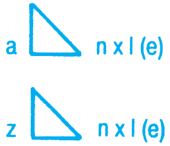
No.	Designation of Welds	Definition		Inscription
1	Butt weld		s : minimum distance from the surface of the part to the bottom of the penetration, which cannot be greater than the thickness of the thinner part	
2	Butt weld between plates with raised edges		s : minimum distance from the external surface of the weld to the bottom of the penetration	
3	Continuous fillet weld		a : height of the largest isosceles triangle that can be inscribed in the section z : side of the largest isosceles triangle that can be inscribed in the section	
4	Intermittent fillet weld		l : length of weld (without end craters) (e) : distance between adjacent weld elements n : number of weld elements a } z } (see No. 3)	

TABLE 26.3 ■ ISO symbols—main dimensions. (continued)

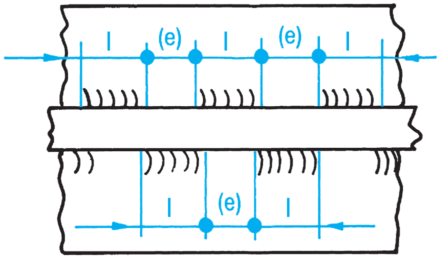
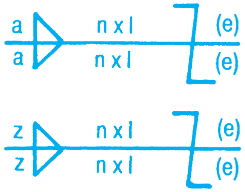
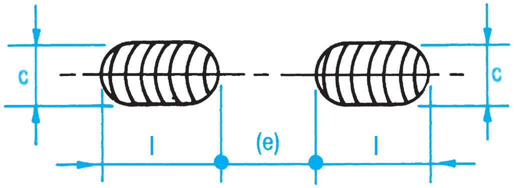
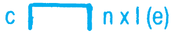
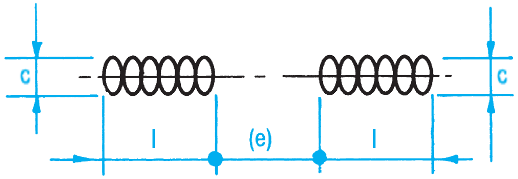
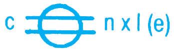
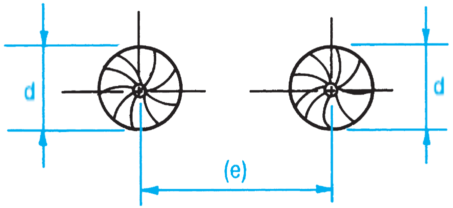
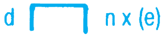
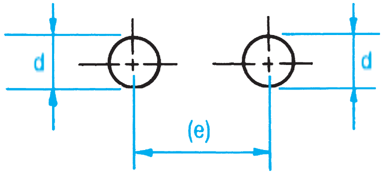
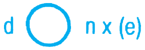
No.	Designation of Welds	Definition		Inscription
5	Staggered intermittent fillet weld		l (e) n } (see No. 4) a z } (see No. 3)	 a n x l (e) a n x l (e) z n x l (e) z n x l (e)
6	Plug or slot weld		l (e) n } (see No. 4) c : width of slot	
7	Seam weld		l (e) n } (see No. 4) c : width of weld	
8	Plug weld		n : (see No. 4) (e) : spacing d : diameter of hole	
9	Spot weld		n : (see No. 4) (e) : spacing d : diameter of spot	

TABLE 26.3 ■ ISO symbols—main dimensions. (concluded)

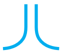
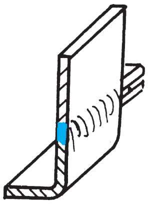
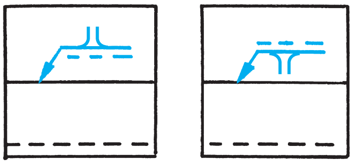
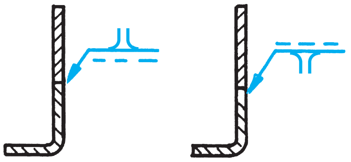
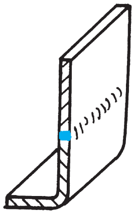
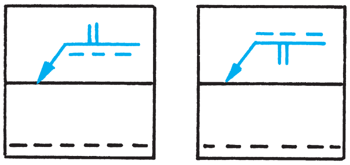
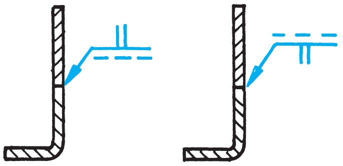
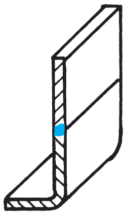
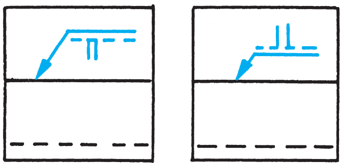
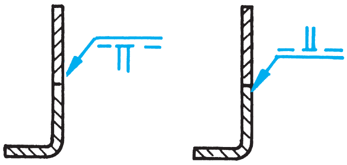
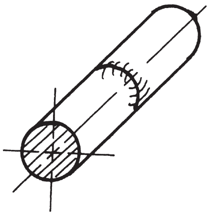
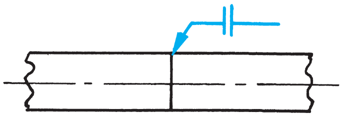
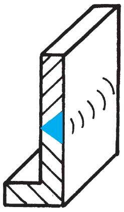
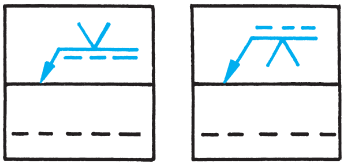
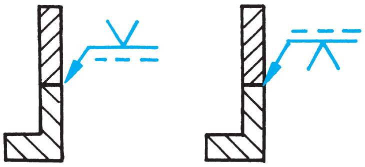
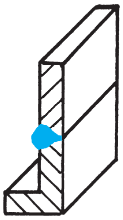
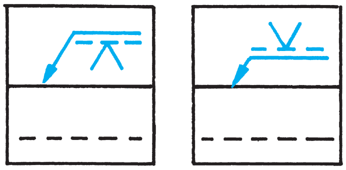
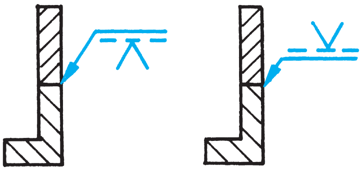
No.	Designation Symbol	Illustration	Symbolization	
			either	or
1	Butt weld between plates with raised edges 			
2	Square butt weld ‖			
3				
4				
5	Single-V butt weld ∨			
6				

TABLE 26.4 ■ Examples of the use of elementary symbols. (continued)

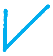
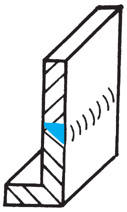
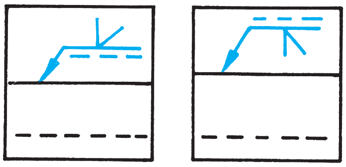
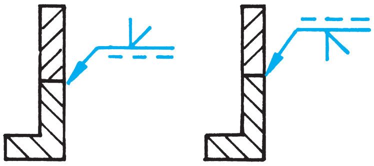
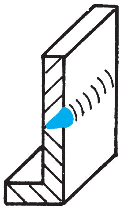
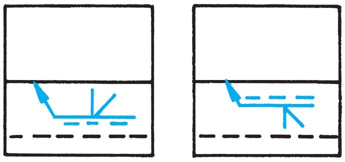
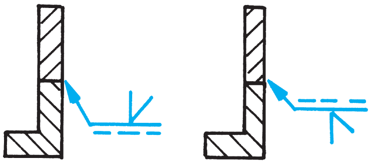
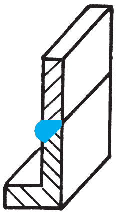
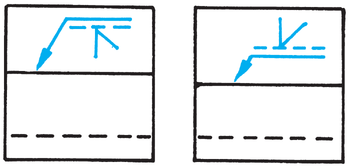
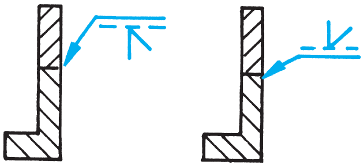
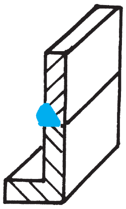
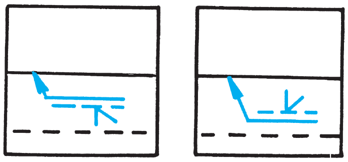
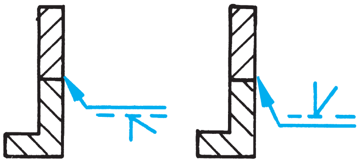
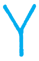
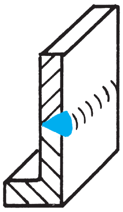
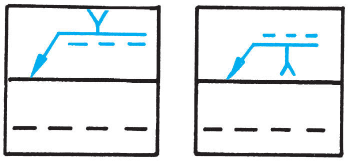
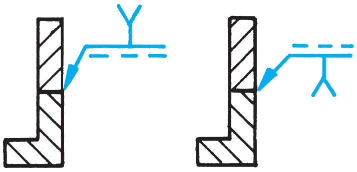
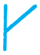
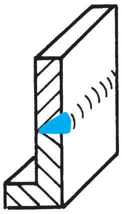
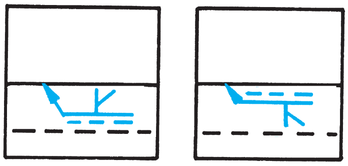
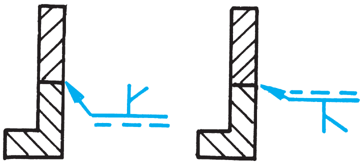
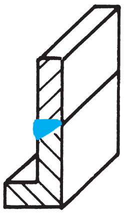
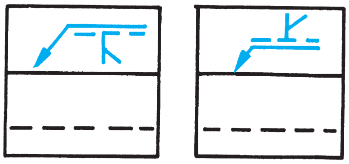
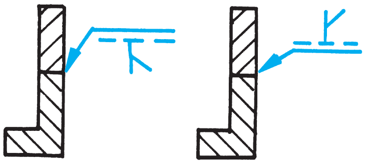
No.	Designation Symbol	Illustration	Symbolization	
			either	or
7	Single-bevel butt weld 			
8				
9				
10				
11	Single-V butt weld with broad root face 			
12	Single-bevel butt weld with broad root face 			
13				

TABLE 26.4 ■ Examples of the use of elementary symbols. (continued)

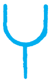
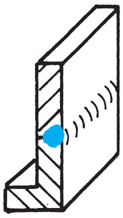
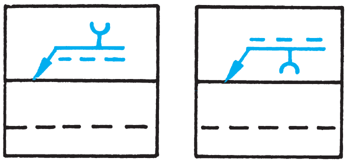
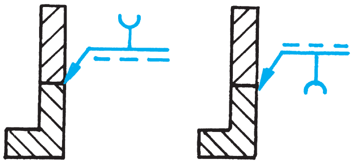
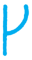
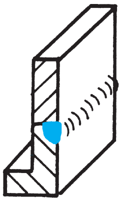
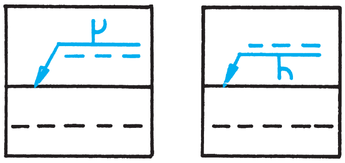
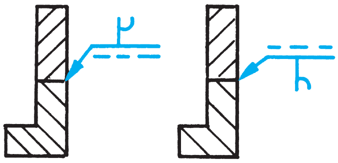
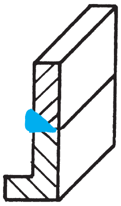
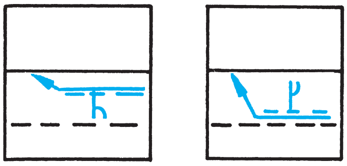
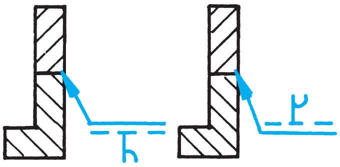
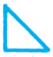
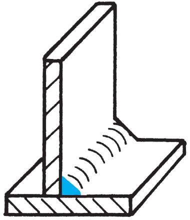
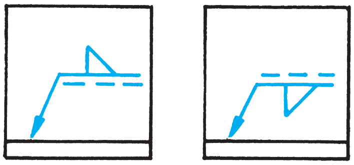
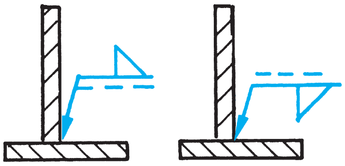
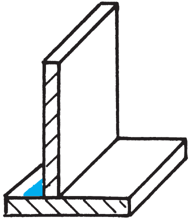
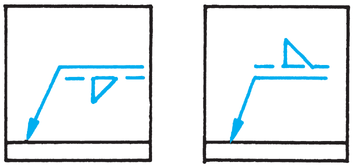
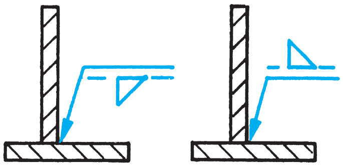
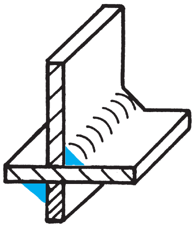
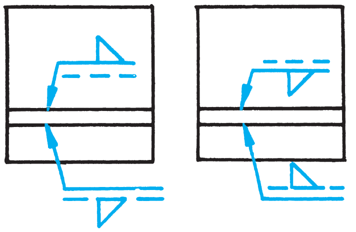
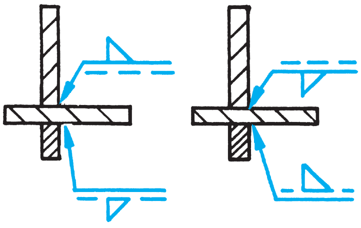
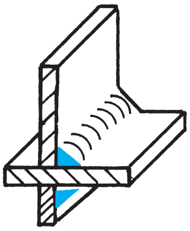
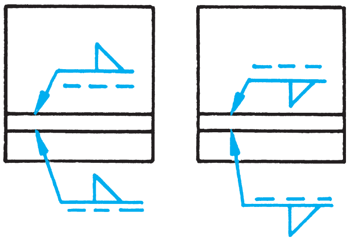
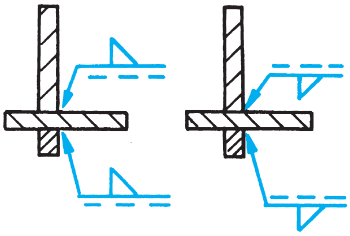
No.	Designation Symbol	Illustration	Symbolization	
			either	or
14	Single-U butt weld 			
15	Single-J butt weld 			
16				
17	Fillet weld 			
18				
19				
20				

TABLE 26.4 ■ Examples of the use of elementary symbols. (continued)

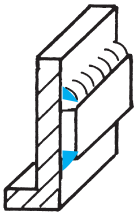
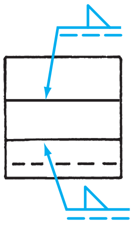
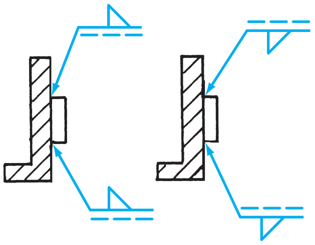
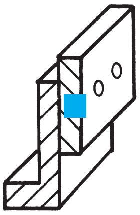
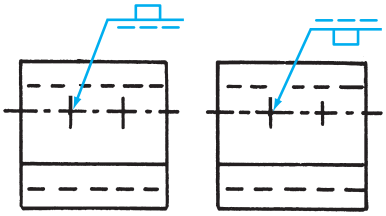
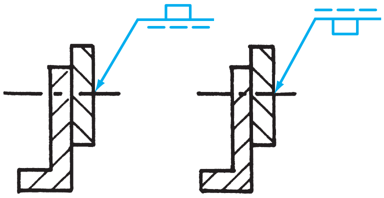
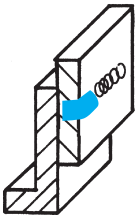
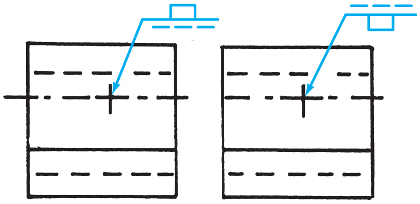
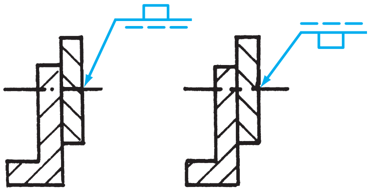
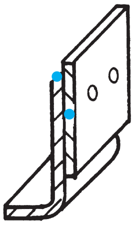
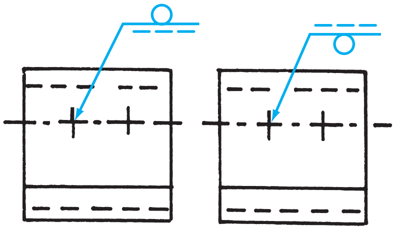
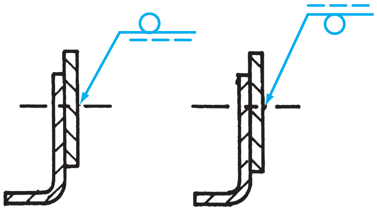
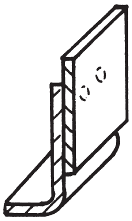
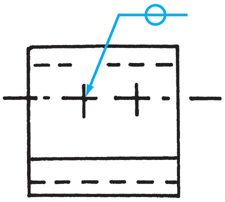
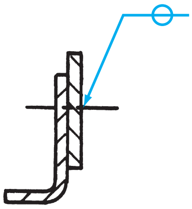
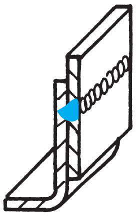
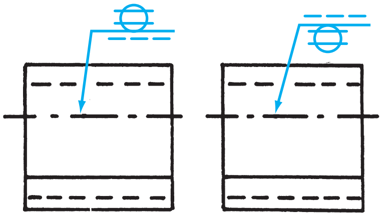
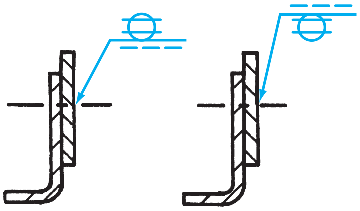
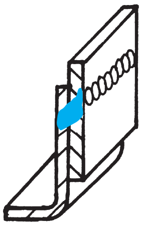
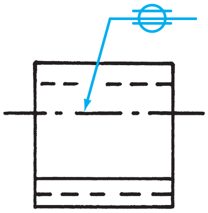
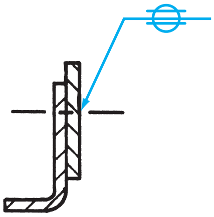
No.	Designation Symbol	Illustration	Symbolization either	Symbolization or
21	Fillet weld ◺			
22	Plug weld ⊓			
23				
24	Spot weld ○			
25				
26	Seam weld ⊖			
27				

TABLE 26.4 ■ Examples of the use of elementary symbols. (concluded)

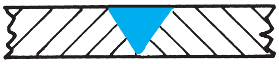
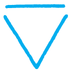
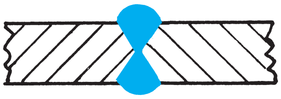
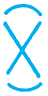
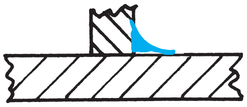
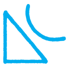
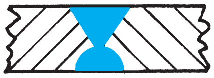
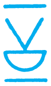
Designation	Illustration	Symbol
Flat (flush) single-V butt weld		
Convex double-V butt weld		
Concave fillet weld		
Flat (flush) single-V butt weld with flat (flush) backing run		

TABLE 26.5 ■ Examples of application of supplementary symbols.

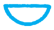
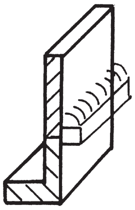
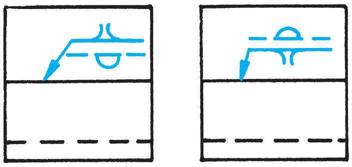
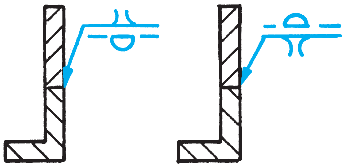
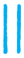
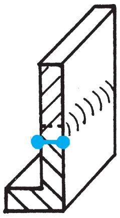
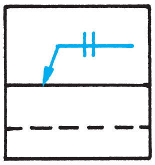
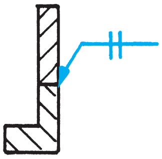
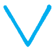
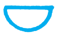
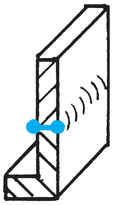
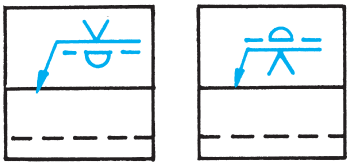
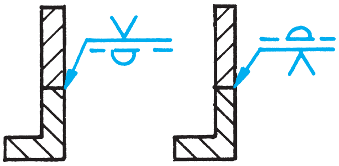
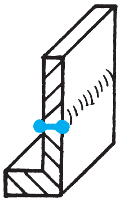
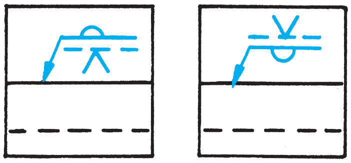
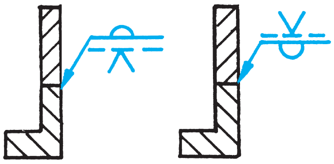
	Designation		Symbolization	
No.	Symbol	Illustration	either	or
1	Butt weld between plates with raised edges and backing run 			
2	Square butt weld  welded from both sides			
3	Single-V butt weld  and backing run 			
4				

TABLE 26.6 ■ Examples of combinations of elementary symbols. (continued)

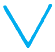
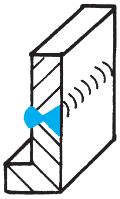
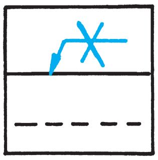
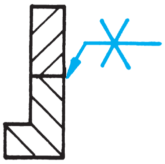
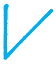
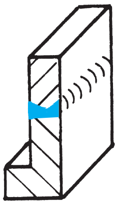
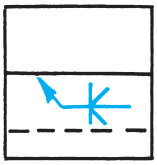
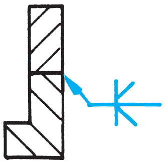
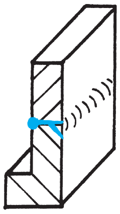
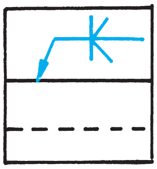
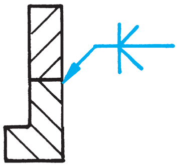
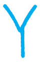
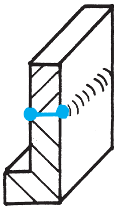
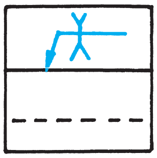
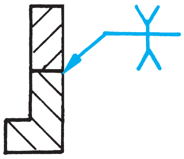
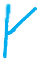
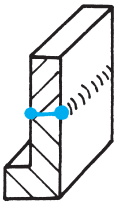
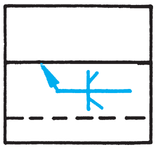
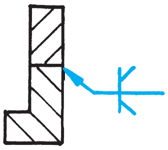
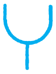
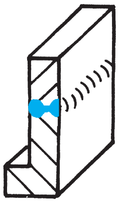
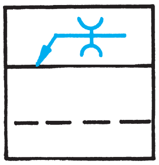
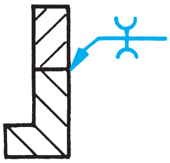
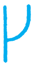
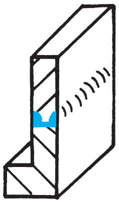
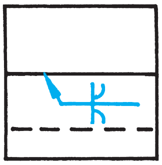
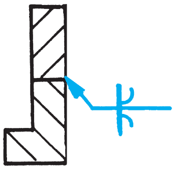
No.	Designation Symbol	Illustration	Symbolization	
			either	or
5	Double-V butt weld  (X weld)			
6	Double-bevel butt weld 			
7				
8	Double-V butt weld with broad root face 			
9	Double-bevel butt weld with broad root face 			
10	Double-U butt weld 			
11	Double-J butt weld 			

TABLE 26.6 ■ Examples of combinations of elementary symbols. (continued)

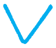
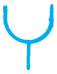
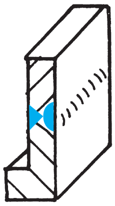
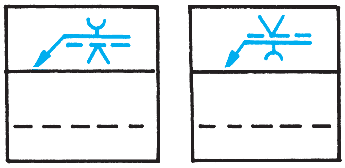
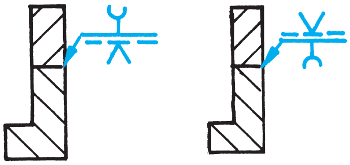
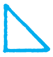
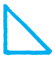
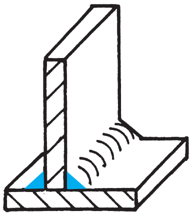
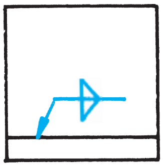
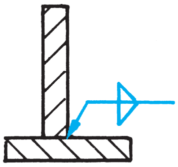
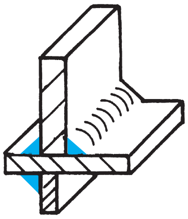
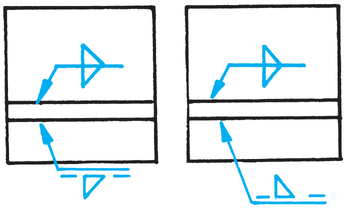
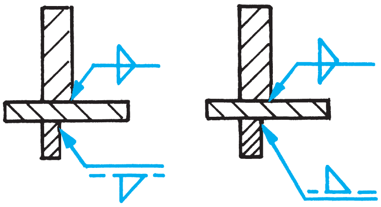
No.	Designation Symbol	Illustration	Symbolization	
			either	or
12	Single-V butt weld  and single-U butt weld 			
13	Fillet weld  and fillet weld 			
14				

TABLE 26.6 ■ Examples of combinations of elementary symbols. (concluded)

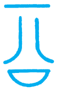
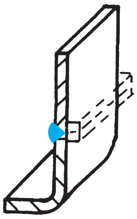
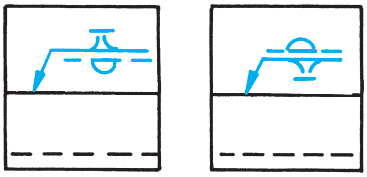
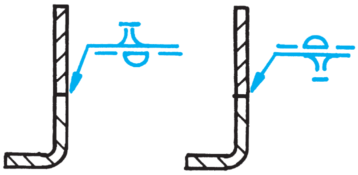
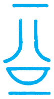
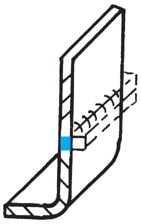
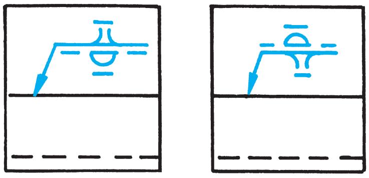
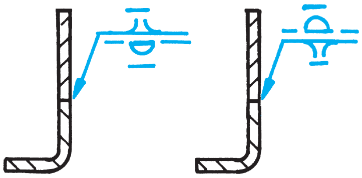
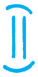
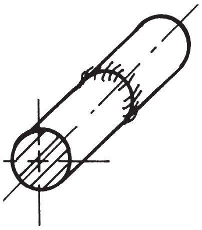
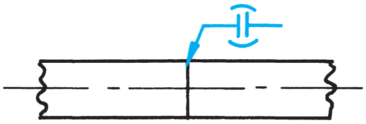
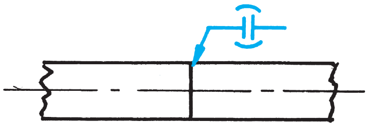
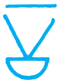
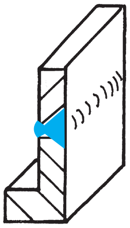
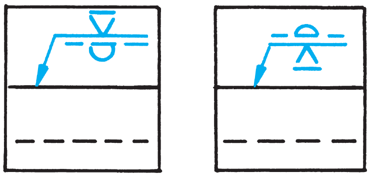
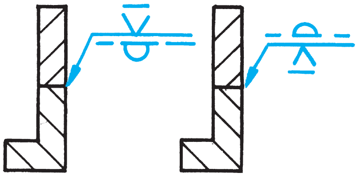
No.	Designation Symbol	Illustration	Symbolization	
			either	or
1				
2				
3				
4				

TABLE 26.7 ■ Examples of combinations of elementary and supplementary symbols.

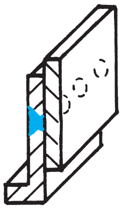
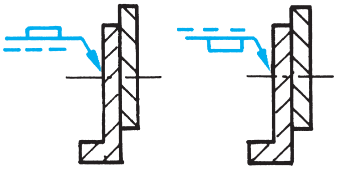
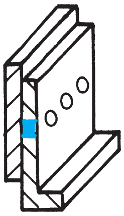
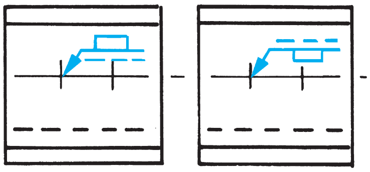
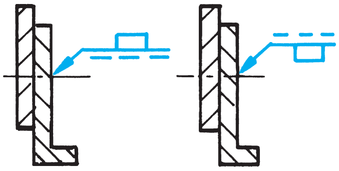
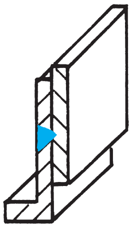
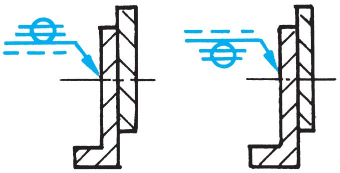
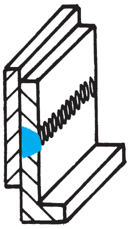
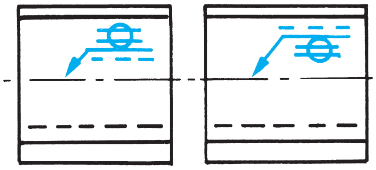
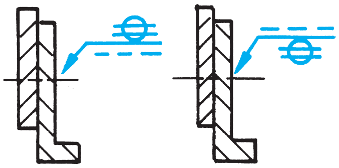
No.	Illustration	Symbolization	
		either	or
1		—	
2			
3		—	
4			

TABLE 26.8 ■ Examples of exceptional cases. (continued)

Note: When the arrow cannot point to a joint, symbolization cannot be used.

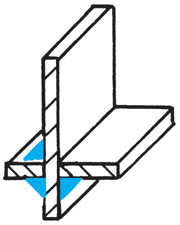
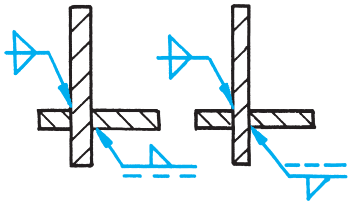
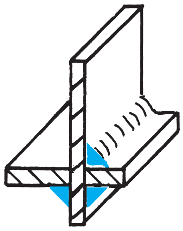
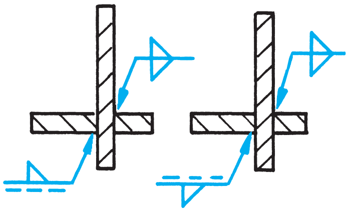
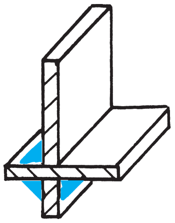
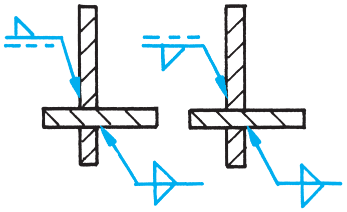
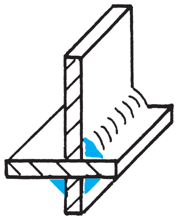
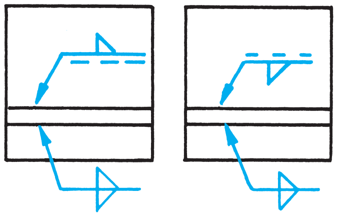
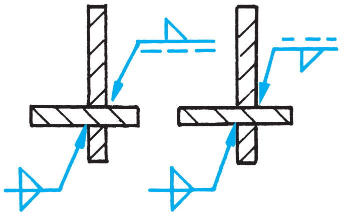
No.	Illustration	Symbolization either	or
5		not recommended	
6		not recommended	
7		not recommended	
8			

TABLE 26.8 ■ Examples of exceptional cases. (concluded)

ISO SYMBOLS

No.	Designation	Symbol
1	Butt weld between plates with raised edges	
2	Square butt weld	
3	Single-V butt weld	
4	Single-bevel butt weld	
5	Single-V butt weld with broad root face	
6	Single-bevel butt weld with broad root face	
7	Single-U butt weld (parallel or sloping sides)	
8	Single-J butt weld	
9	Backing run	
10	Fillet weld	
11	Plug weld	
12	Slot weld	

AWS SYMBOLS

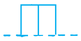
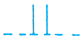
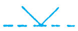
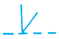
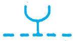
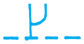
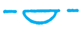
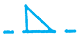
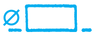
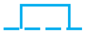
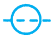
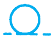
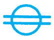
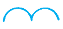
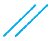
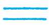
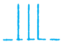
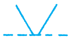
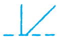
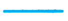
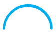
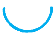
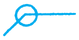
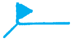
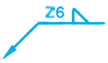
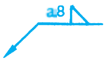
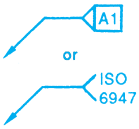
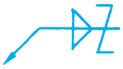
No.	Designation	Symbol
1	Edge weld	
2	Square groove weld	
3	V-groove weld	
4	Bevel groove weld	
5	———————	No symbol
6	———————	No symbol
7	U-groove weld	
8	J-groove weld	
9	Back or backing weld	
10	Fillet weld	
11	Plug weld	
12	Slot weld	

TABLE 26.9 ■ Comparison of ISO symbols to AWS symbols. (continued)

ISO SYMBOLS

No.	Designation	Symbol
13	Spot (projection) weld	
14	Spot weld	
15	Seam weld	
16	— — — — — — —	No symbol
17	Surfacing weld	
18	— — — — — — —	No symbol
19	— — — — — — —	No symbol
20	Permanent backing strip used Removable backing strip used	M MR
21	Inclined joint	
22	Surface joint	
23	Edge weld	
24	Steeped-flanked single-V butt weld	
25	Steeped-flanked single-V bevel butt weld	
26	Fold joint	
27	Flat (usually finished)	
28	Convex	
29	Concave	
30	Toes shall be blended smoothly	
31	Peripheral weld	
32	Field or site weld	
33	— — — — — — —	No symbol
34	— — — — — — —	No symbol
35	— — — — — — —	No symbol
36	— — — — — — —	No symbol
37	Fillet weld leg size (size is preceded by lowercase "z")	 z6
38	Fillet weld throat thickness (thickness is preceded by the letter "a")	 a8
39	Tail of welding symbol for reference	 A1 or ISO 6947
40	Staggered intermittent fillet weld	

AWS SYMBOLS

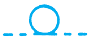
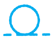
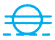
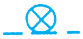
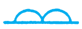
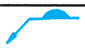
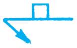
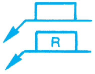
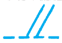
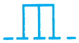
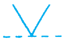
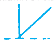
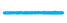
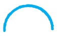
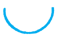
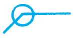
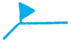
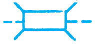
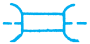
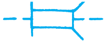
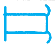
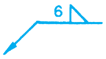
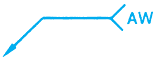
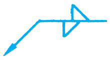
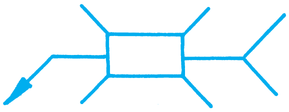
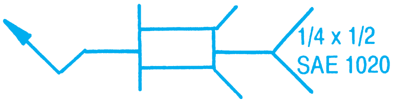
No.	Designation	Symbol
13	Projection weld	
14	Spot weld	
15	Seam weld	
16	Stud weld	
17	Surfacing weld	
18	Melt-thru weld	
19	Consumable insert (square)	
20	Permanent backing or spacer Backing to be removed	 R
21	Scarf	
22	— — — — — — —	No symbol
23	Edge weld	
24	V-groove weld	
25	Bevel groove	
26	— — — — — — —	No symbol
27	Flush or flat contour	
28	Convex contour	
29	Concave	
30	No such designation	No symbol
31	Weld-all-around	
32	Field weld	
33	Double V-groove with spacer	
34	Double U-groove with spacer	
35	Double bevel groove with spacer	
36	Double J-groove with spacer	
37	Fillet weld leg size	 6
38	— — — — — — —	No similar symbol designation
39	Tail of welding symbol for reference information	 AW
40	Staggered intermittent fillet weld	

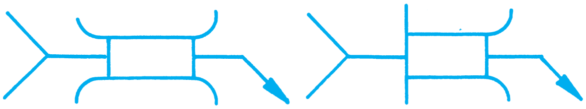
TABLE 26.9 ■ Comparison of ISO symbols to AWS symbols. (concluded)



Double-V-groove



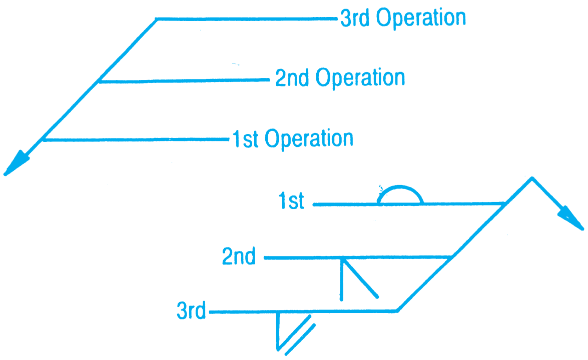
Double-bevel-groove



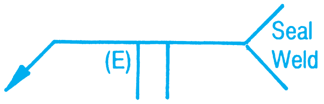
Double-U-groove

Double-J-groove

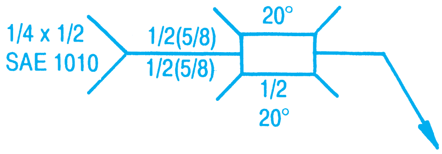
Combinations of groove weld symbols with spacer symbol



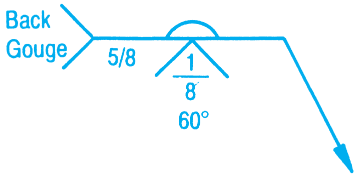
Multiple reference lines to indicate sequence of operations



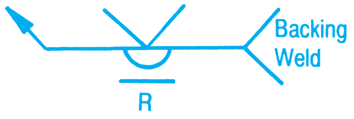
Reference to seal weld



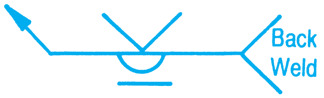
Reference in tail to spacer size and SAE specification



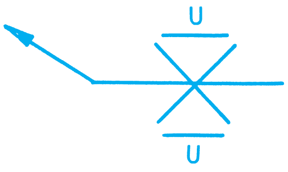
Reference in tail signifying to back gouge



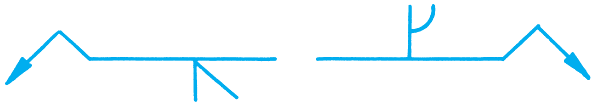
Reference to backing weld



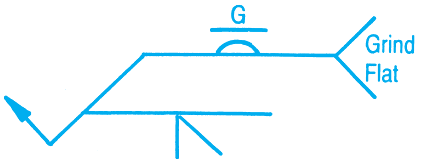
Reference to back weld



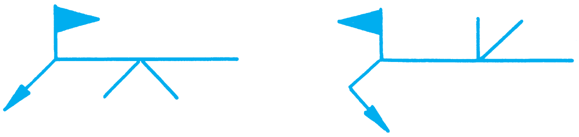
U — Finishing method unspecified



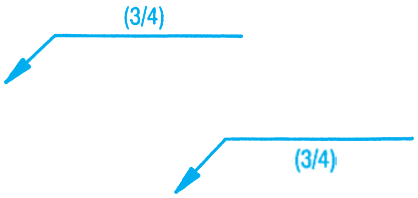
Broken arrow for pointing to joint member to be prepared



Reference to grind flat



Flag points in either direction



Joint penetration not specified, size of groove weld is specified

TABLE 26.10 ■ Additional AWS symbols for which there are no comparable ISO symbols. (continued)

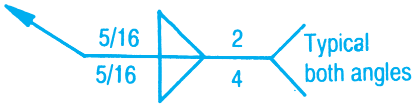
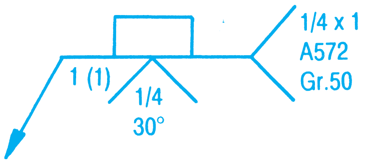
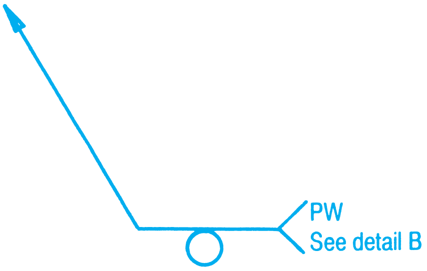
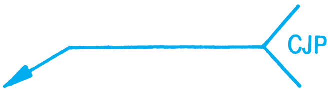
 Typical reference in tail	 Reference in tail to backing strip size and material
 Detail reference in tail	 Joint preparation not specified, complete joint penetration required, as indicated by reference in tail

TABLE 26.10 ■ Additional AWS symbols for which there are no comparable ISO symbols. (concluded)

APPLICATION OF ISO SYMBOLS TO DRAWINGS (FIRST-ANGLE ORTHOGRAPHIC PROJECTION)

ISO symbols for weld representations are generally found on drawings prepared with the views shown in first-angle orthographic projection. The symbol for indicating this is illustrated in Figure 26.7.

Dimensioning on drawings is in the metric system, usually given in millimeters (mm).

In first-angle projection, the top view is shown below the front view, the left side view is shown to the right of the front view, and the right side is shown to the left of the front view, Figure 26.8. A typical first-angle projection drawing is illustrated in Figure 26.9.

The three most commonly used views for both first-angle projection and third-angle projection are the front top and right or left side views. Note the second- and fourth-angle projections are not used for working drawings.

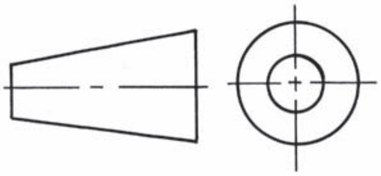


FIGURE 26.7 ■ Symbol for first-angle projection.

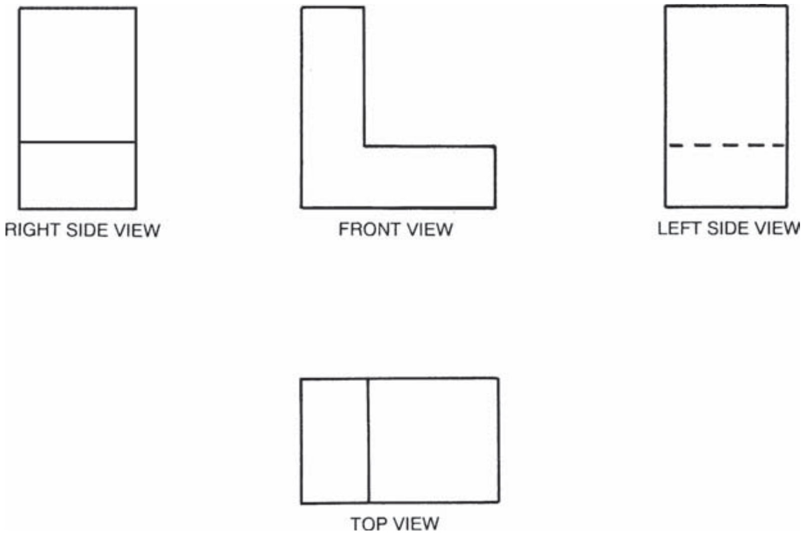


FIGURE 26.8 ■ Location of views in first-angle projection.

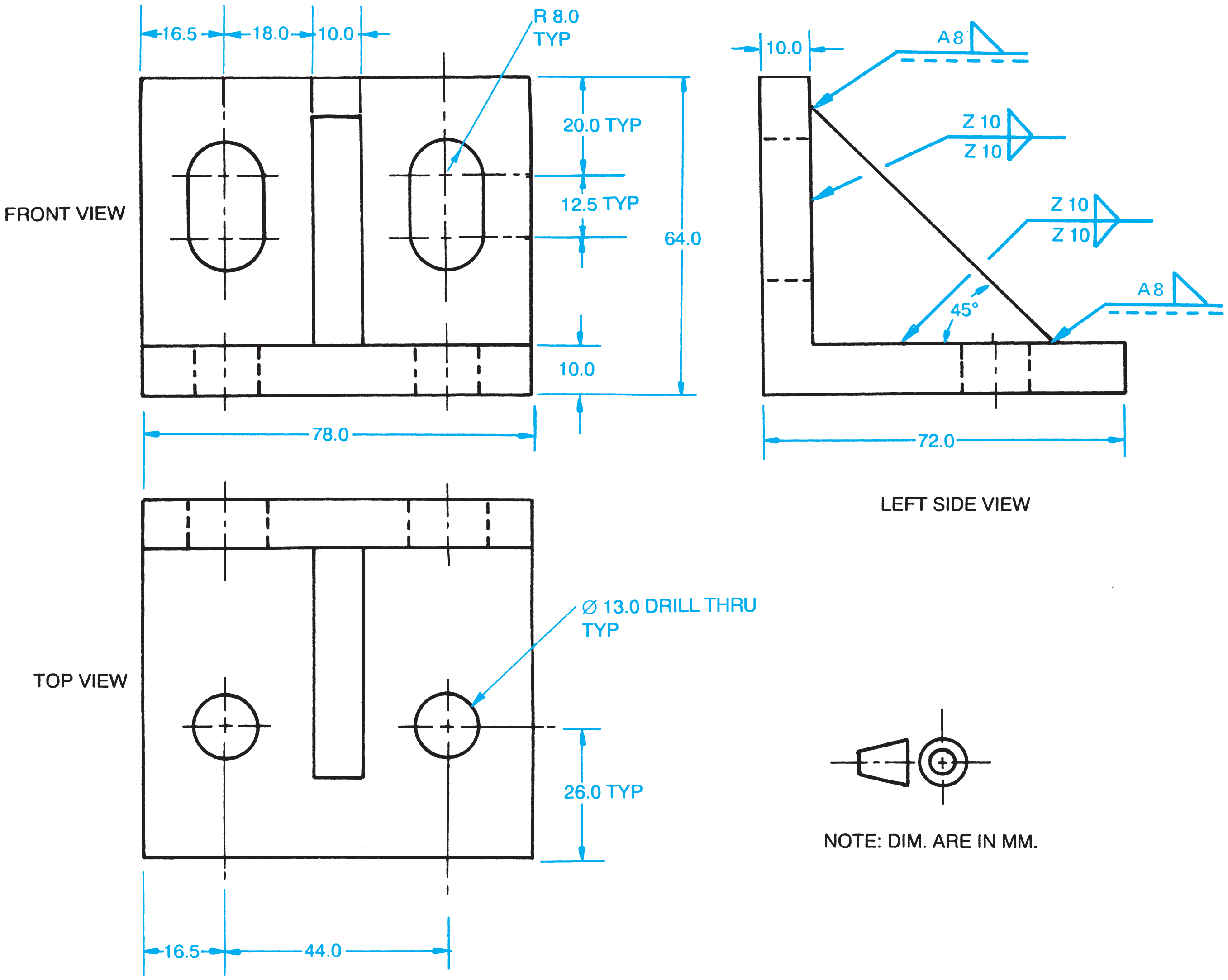


FIGURE 26.9 ■ A typical first-angle orthographic projection three-view drawing.

First-Angle Orthographic Projection

The arrangement and shape of views for first-angle projection is derived from viewing an object located within the three planes of the first quadrant of a circle. An identification of each quadrant and each plane is illustrated in Figure 26.10.

In the derivation of views for first-angle projection drawings, (1) the front view is projected to the vertical plane, (2) the top view is projected to the horizontal plane, and (3) the left side view is projected to the profile plane.

When an object is placed within the first quadrant, it is viewed in *front* of each plane and then projected to the plane for deriving the front, left side, and top views, Figure 26.11. By rotating the profile and horizontal planes 90° to a single plane, the shapes and relative positions of the views are shown as they would appear on a first-angle projection drawing.

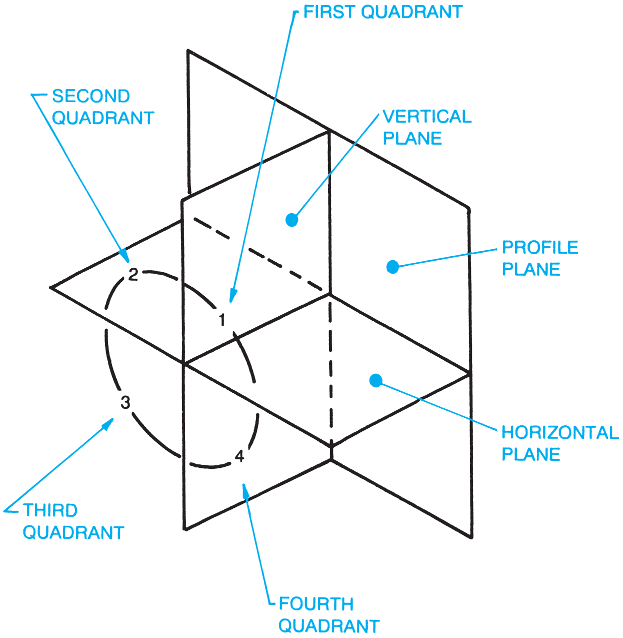


FIGURE 26.10 ■ Identification and respective locations of quadrants and planes.

Note: The symbol used to indicate a plane is a straight line with a dot at one end (———●) and placed on the plane.

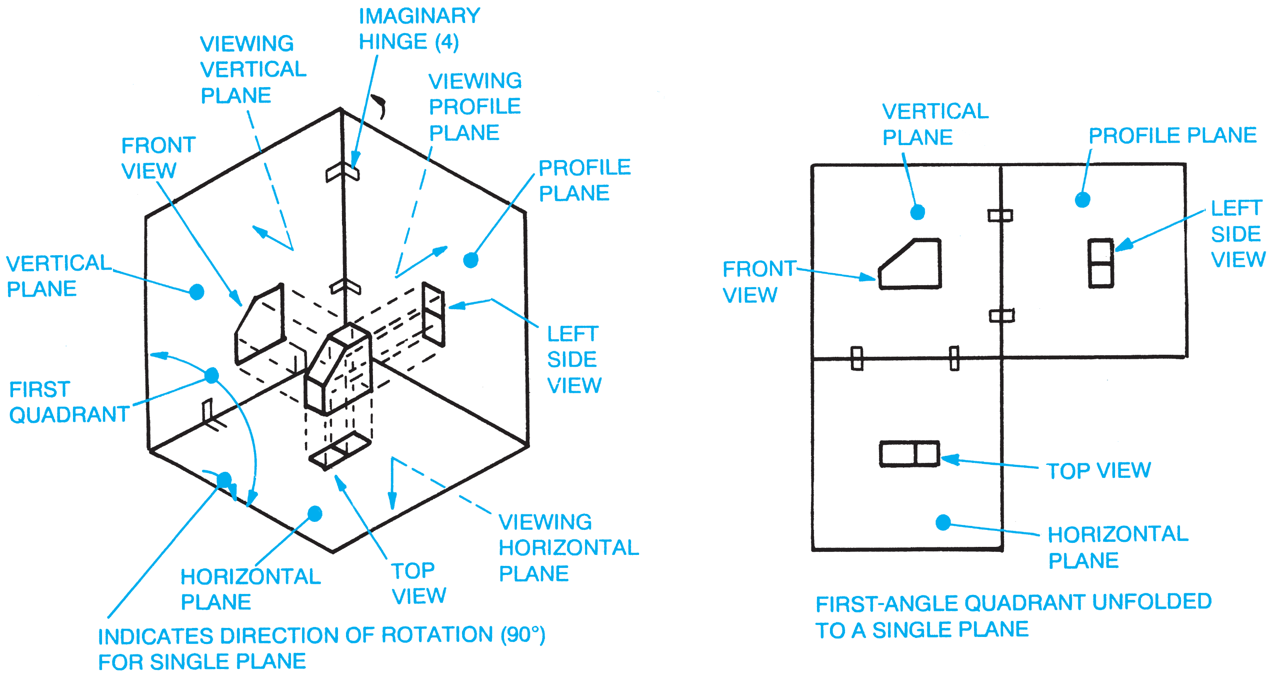
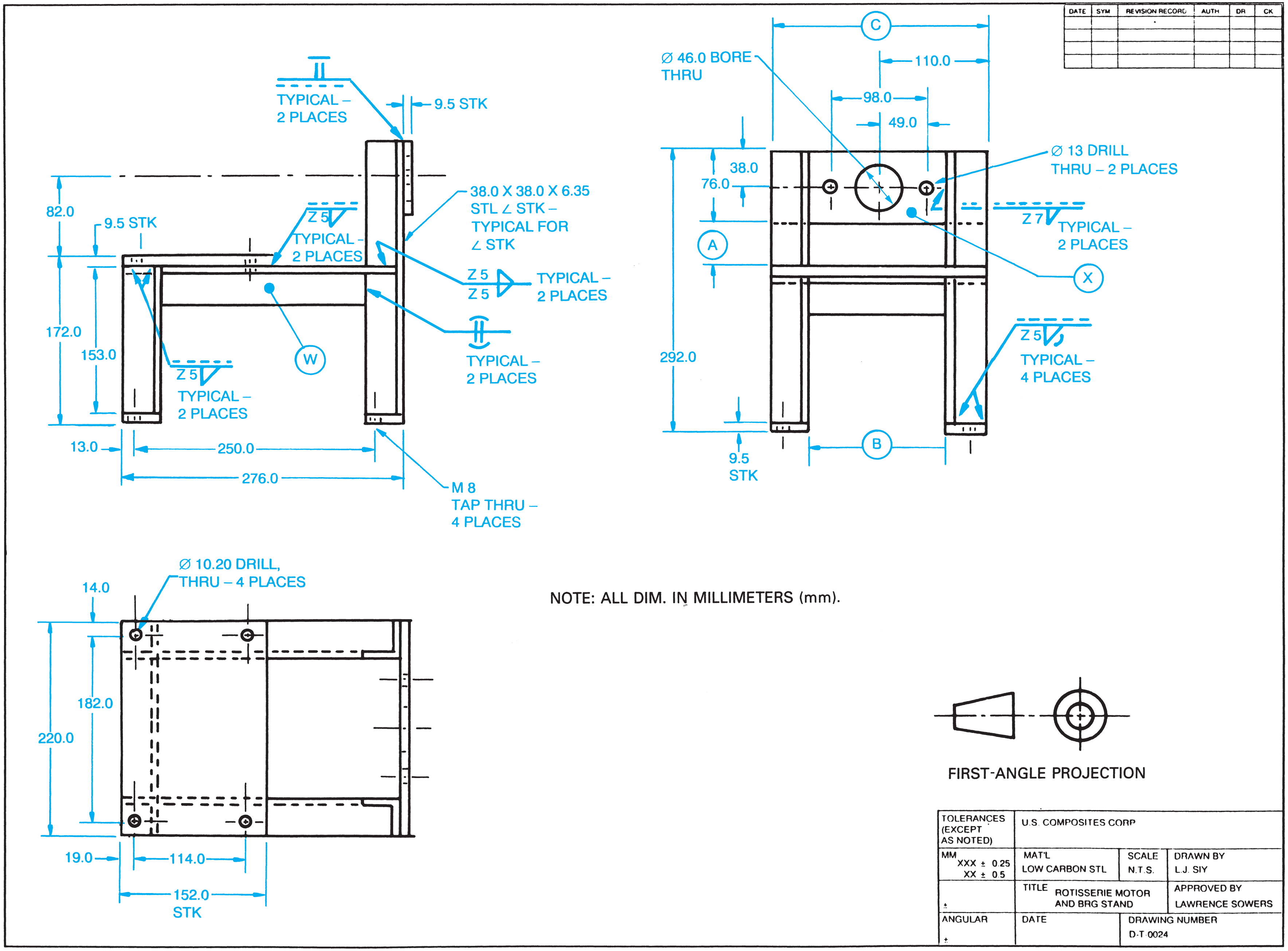


FIGURE 26.11 ■ Deriving views for first-angle projection drawings.


DATE
SYM
REVISION RECORD
AUTH
DR
CK
TYPICAL – 2 PLACES
9.5 STK
82.0
9.5 STK
Z 5
TYPICAL – 2 PLACES
38.0 X 38.0 X 6.35 STL ∠ STK – TYPICAL FOR ∠ STK
Z 5
Z 5
TYPICAL – 2 PLACES
172.0
153.0
W
Z 5
TYPICAL – 2 PLACES
TYPICAL – 2 PLACES
13.0
250.0
276.0
M 8 TAP THRU – 4 PLACES
C
Ø 46.0 BORE THRU
110.0
98.0
49.0
Ø 13 DRILL THRU – 2 PLACES
38.0
76.0
Z 7
TYPICAL – 2 PLACES
A
X
292.0
Z 5
TYPICAL – 4 PLACES
9.5 STK
B
Ø 10.20 DRILL, THRU – 4 PLACES
14.0
182.0
220.0
19.0
114.0
152.0 STK
NOTE: ALL DIM. IN MILLIMETERS (mm).
FIRST-ANGLE PROJECTION
TOLERANCES (EXCEPT AS NOTED)
MM
XXX ± 0.25
XX ± 0.5
±
ANGULAR
±
U.S. COMPOSITES CORP
MAT'L
LOW CARBON STL
SCALE
N.T.S.
DRAWN BY
L.J. SIY
TITLE
ROTISSERIE MOTOR AND BRG STAND
APPROVED BY
LAWRENCE SOWERS
DATE
DRAWING NUMBER
D-T 0024

UNIT 26: REVIEW A

Refer to the drawing, Rotisserie Motor and BRG Stand, page 330.

Graph paper is provided at the end of this review for your use.

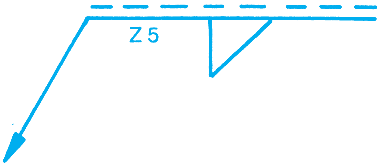
1. What type of working drawing is illustrated?

2. a. What type of orthographic projection is illustrated?

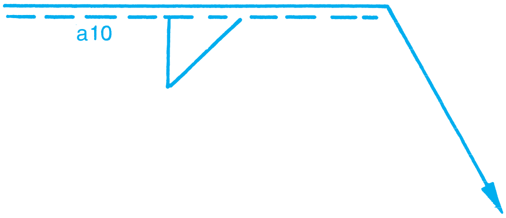
   b. How was this determined?

3. Identify the views that are shown.

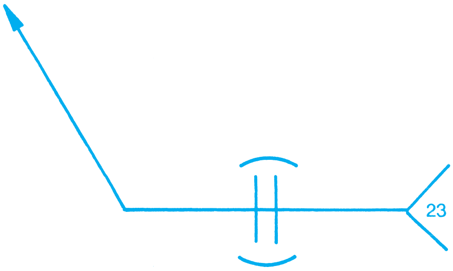
4. a. Give the significance of each of the elements found on the following ISO symbols.



(1)



(2)



(3)

b. Identify whether the welds are to be arrow side, other side, or both sides.

(1)

(2)

(3)

5. Identify a reference dimension found on the drawing.

6. a. How many millimeters of angle stock are required to make the part? Allow 2.0 mm for each cut.

   b. List the number and length of pieces required.

No. Required	Length

7. List the sizes (in mm) of 9.5 mm plate stock required.

No. Req'd	Width	Length

8. a. List dimensions:

Ⓐ ______________________________

Ⓑ ______________________________

Ⓒ ______________________________

b. In which view can dimension Ⓒ be found without performing any calculations?

____

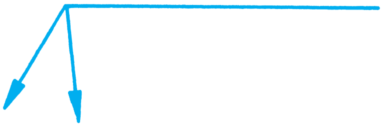
9. a. Give the mm size of the tap drill required for tapping the M8 thread. Refer to Appendix 6 for obtaining this information.

____

b. What fractional number or letter size of drill could be substituted? Refer to Appendix 4 for obtaining this information.

____

10. a. Is the following multiple arrow illustration an accepted ISO standard?



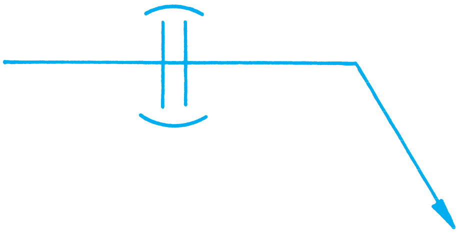
____

b. Is it an acceptable AWS standard?

____

11. Why is a dashed line not shown as a part of the following ISO symbol?

____



12. What is the significance of the following abbreviations?

MAT'L ______________________________

STK ______________________________

N.T.S. ______________________________

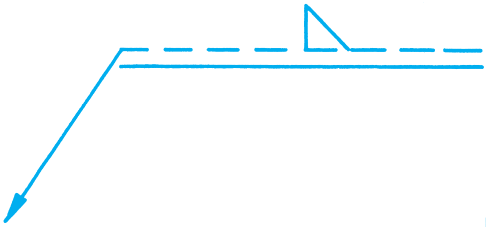
BRG ______________________________

13. What is the significance of the note "TYPICAL 4 PLACES"?

____

____

14. How would a throat size dimension of 7 mm be shown on the following ISO symbol?



____

15. What are the maximum and minimum allowable sizes for the following dimensions?

276.0—Maximum ______________________________

Minimum ______________________________

6.35—Maximum ______________________________

Minimum ______________________________

16. Give the significance of M8 as found on the drawing.

M ______________________________

8 ______________________________

17. How many 13.0 mm drilled holes are required?

____

18. How many tapped holes are required?

____

19. How many bored holes are required?

____

20. What is the tolerance allowable (plus and minus) for the following dimensions?

a. 9.5 ______________________________

b. 98.0 ______________________________

21. In which view(s) are lines missing for indicating drilled holes?

____

22. Sketch a right side view of the complete unit. Use graph section for answer.

23. Sketch a right isometric of the complete unit. Use graph section for answer.

24. What is the tolerance specified for the bored-hole?

25. a. Should the threaded holes be tapped before execution of the welds?

b. Give reason(s) for your answer.

26. a. Should the drilled holes and bore in part Ⓧ be made before welding?

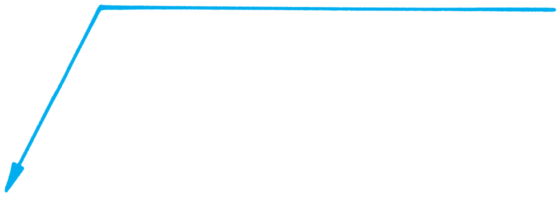
b. Give reason(s) for your answer.

27. What special preparation of part Ⓧ is required before welding?

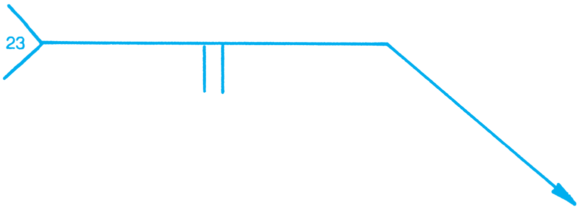
28. a. Should the drilled holes in part Ⓦ be made before welding?

b. Give reason(s) for your answer.

29. If an intermittent, other side, fillet weld were required, how would this be shown (exclusive of dimensions) on the symbol that follows?



30. a. If a flat ground finish were required, how would this be shown on the ISO symbol that follows?



b. Is this symbol shown correctly? If not, correct it.

c. What is the significance of the number found in the tail of the symbol?

31. Prepare a bottom view (first-angle orthographic projection) of the complete unit. Use graph section that follows.

UNIT 26: REVIEW B

Graph paper is provided at the end of this review for your use.

1. a. Sketch the components of an ISO weld symbol.

   b. Identify each component.

   ____

   ____

   ____

2. a. Sketch three "Complimentary Indications" that may be added to an ISO weld symbol. Apply each to an ISO weld symbol.

   b. Identify each.

   ____

   ____

   ____

3. a. Sketch two elementary ISO weld symbols that are not included in the basic American Welding Society (AWS) weld symbols.

   b. Identify each.

   ____

   ____

4. Sketch five ISO weld symbols that are identical to AWS weld symbols. Show these in the table format that follows.

AWS	ISO

5. a. Sketch the contour symbols that may be applied to ISO weld symbols.

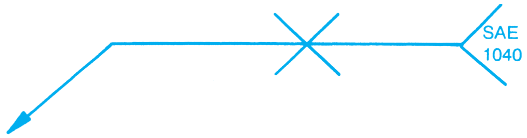
   b. Identify each.

   ____

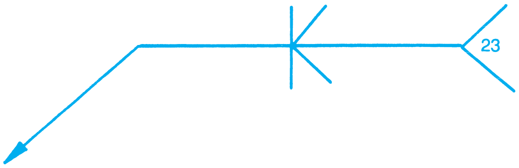
   ____

   ____

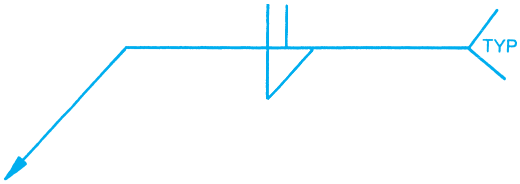
6. a. Identify whether the following symbols have application to ISO, AWS, or to both ISO and AWS.



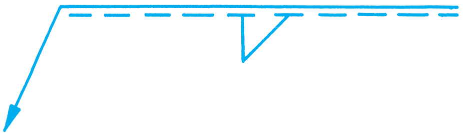
(1) ______________________________



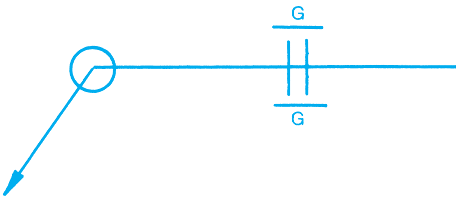
(2) ______________________________



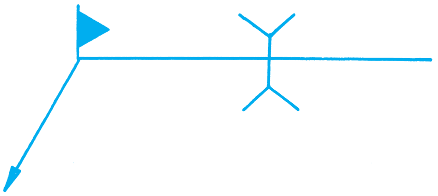
(3) ______________________________



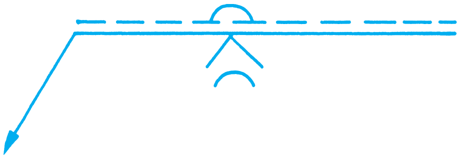
(4) ______________________________



(5) ______________________________



(6) ______________________________



(7) ______________________________

b. Describe the welds indicated by the symbols 1 through 7. Identify whether they are arrow side, other side, or both sides.

(1) ______________________________

____

(2) ______________________________

____

(3) ______________________________

____

(4) ______________________________

____

(5) ______________________________

____

(6) ______________________________

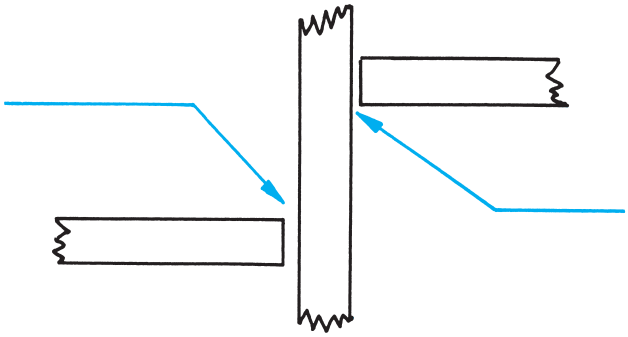
____

(7) ______________________________

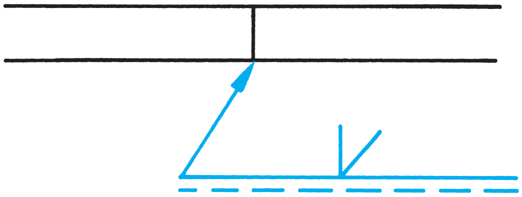
____

7. Sketch the ISO symbol for the following welds.
   a. Plug weld
   b. Seam weld
   c. Single J-butt weld
   d. Butt weld between plates with raised edges
   e. Surfacing weld
   f. Spot weld

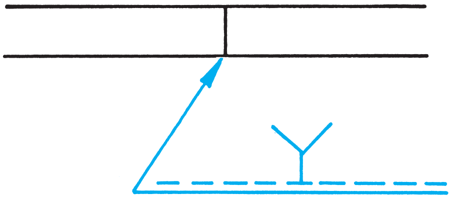
8. On the following sketch identify which are the arrow side and other side of the joints (as recognized by AWS and ISO).



9. a. On the following sketches identify which of the joint members are to be prepared for the weld. Modify each joint to illustrate how the geometry of each joint would appear.



(1) ______________________________



(2) ______________________________

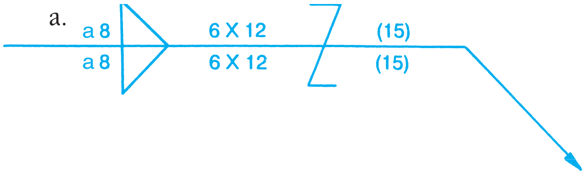
b. Identify the welds required.

(1) ______________________________

(2) ______________________________

10. Interpret the following ISO symbols.

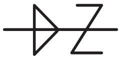
a.



a8 : ______________________________

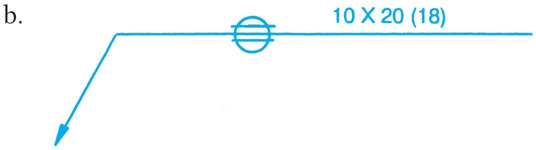
6 × 12 : ______________________________

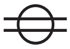
:


: ______________________________

(15) : ______________________________

b.

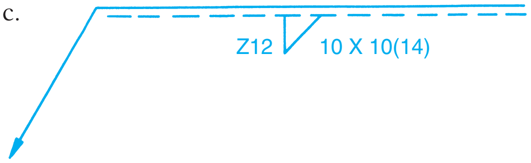


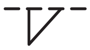
 : ______

10 × 20 : ______

(18) : ______

c.



 : ______

Z12 : ______

10 × 10 : ______

(14) : ______

11. What is the most common system of measurement found on first-angle orthographic projection drawings?

______

______

12. What is the unit most commonly used?

______

______

13. How is the system of measurement signified on a drawing?

______

______

______

14. Identify the three most commonly used views for first-angle and third-angle projection drawings.

______

______

______

15. a. In the sketch that follows, identify each view in terms of first-angle orthographic projection.

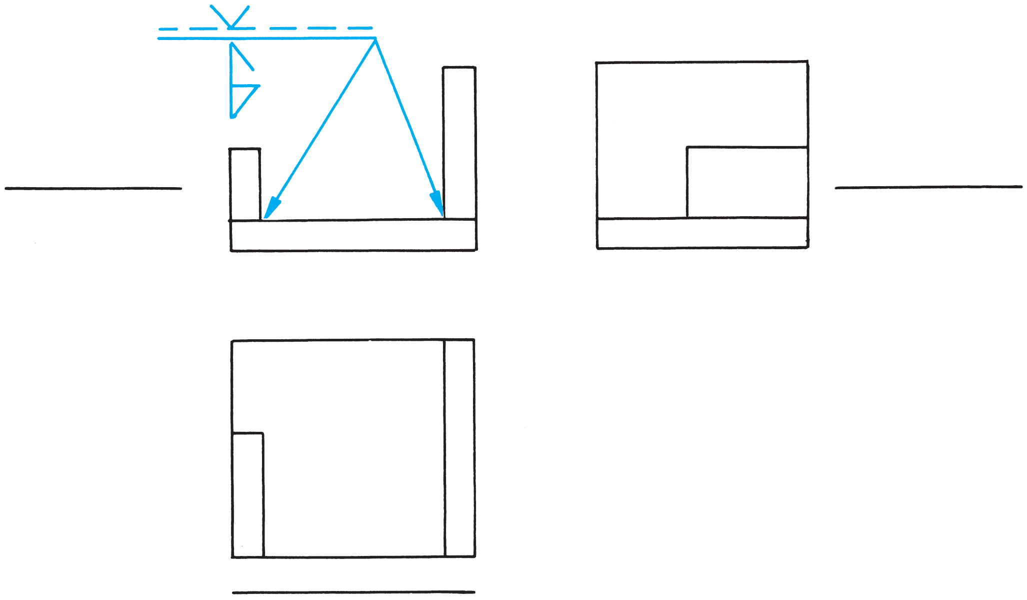
b. Interpret the weld symbols shown in the sketch. Include the type of weld and whether the weld is on the arrow side, other side, or both.

______

______

______

c. Sketch the geometry of the joints to be welded.



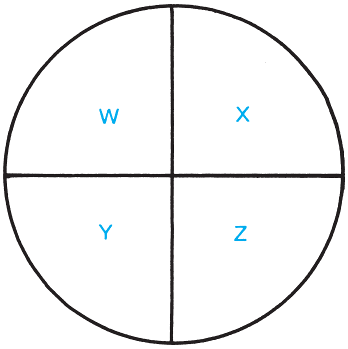
16. In the sketch that follows, identify the quadrant applicable to:

    a. First-angle projection

    ____

    b. Third-angle projection

    ____



17. a. As derived from the three-dimensional drawing that follows, prepare a three-view first-angle orthographic projection drawing that includes a front view, top view, and left side view.

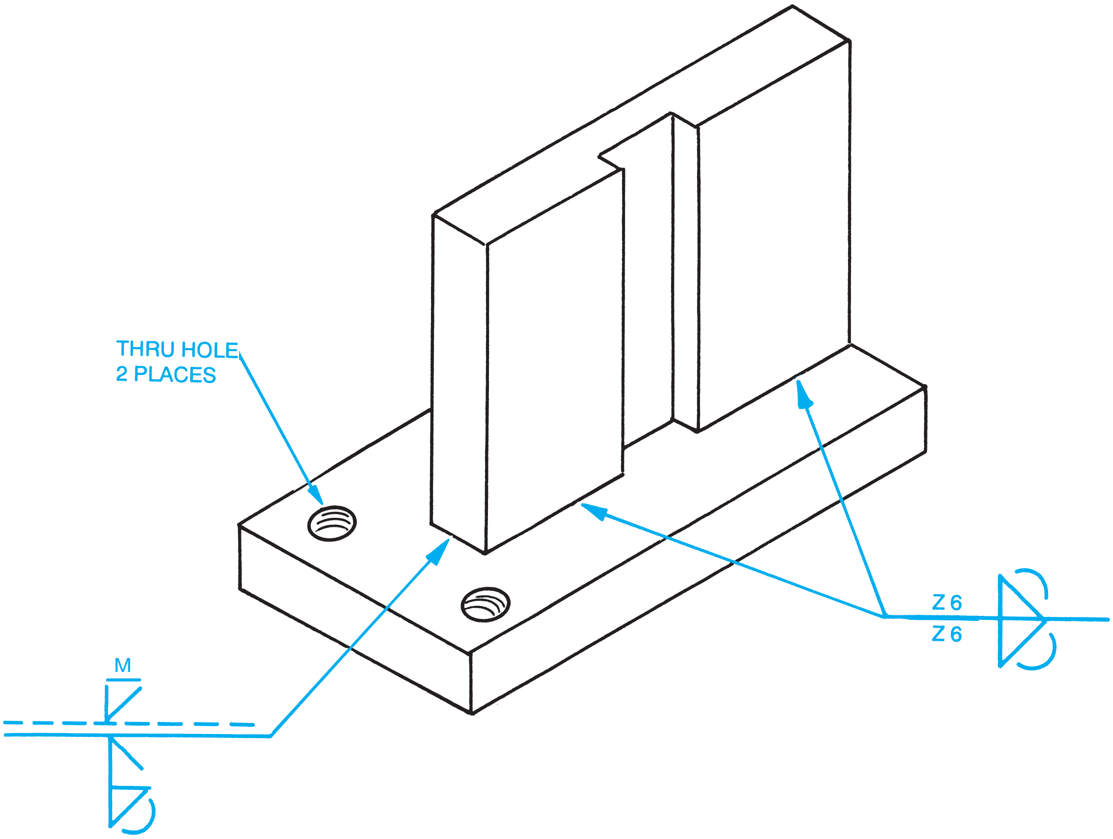
    b. Identify (1) the welds required, (2) their location (arrow side or other side), (3) contour, and (4) method of finish.

    ____

    ____

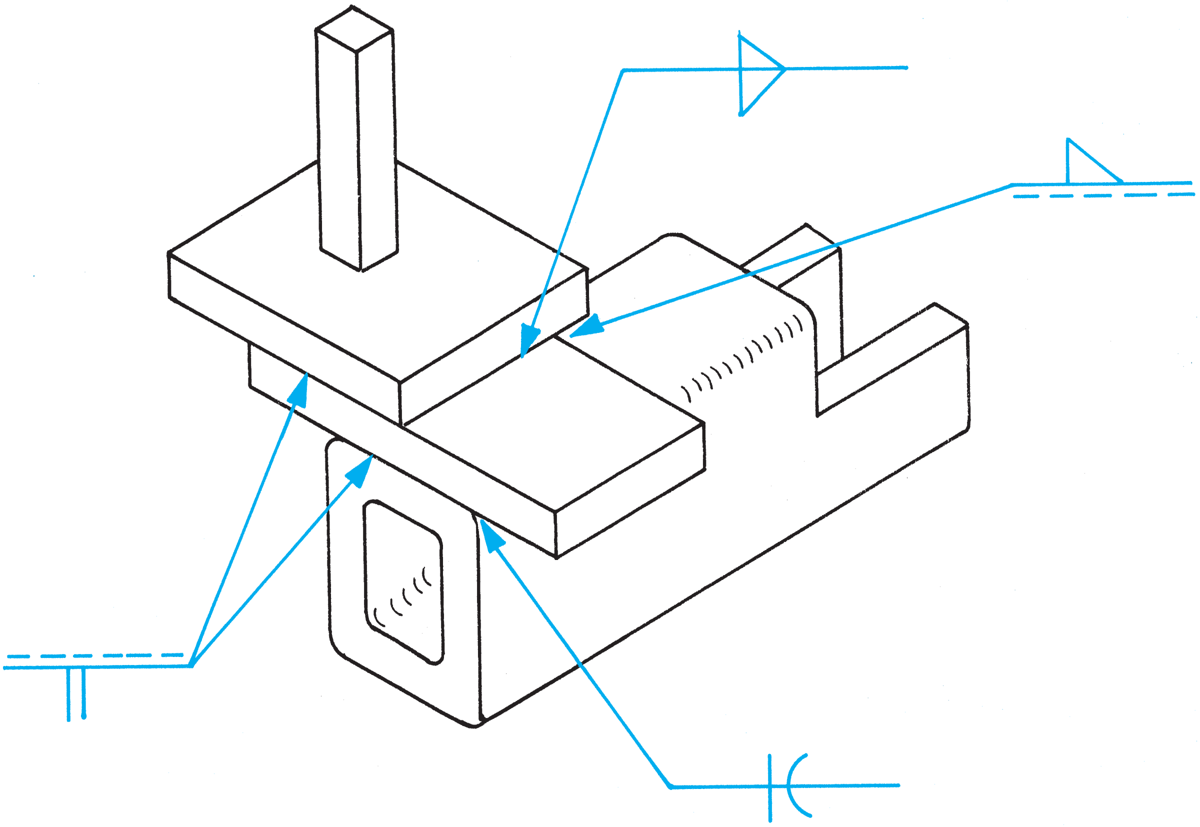
    ____

    ____



18. a. Identify the type of three-dimensional drawing that follows.

____

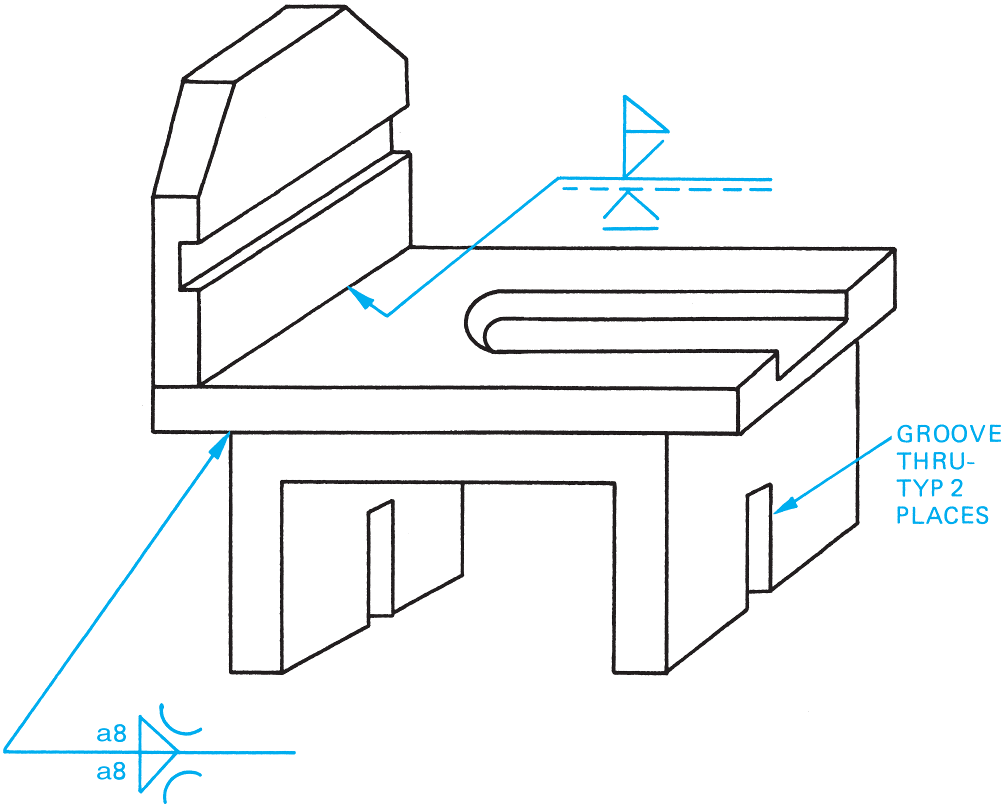


b. Prepare a three-view first-angle orthographic projection drawing which includes front, left side, and bottom views. Use the graph paper that follows this review for this purpose.

c. Apply the weld symbols shown on the three-dimensional drawing to the appropriate views and joints of the first-angle orthographic projection drawing.

19. a. Identify the type of three-dimensional drawing that is illustrated as follows.

____



b. Prepare a three-view first-angle orthographic projection drawing including front, top, and left-side views of the three-dimensional drawing.

c. Apply the weld symbols shown on the three-dimensional drawing to the appropriate views and joints of the first-angle orthographic projection drawing.

27 UNIT

Introduction to Computer Aided Drafting

Computers have increasingly become an integral part of the design and manufacturing environment. The engineering professional and support staff use computers extensively for the production of working and design drawings. These drawings are created using a variety of different drafting and design programs designed to produce two-dimensional and/or three-dimensional (length, width, and depth) drawings, see Figure 27.1 and Figure 27.2.

In addition to drafting and design, software is also available for the creation of three-dimensional solid models and photo realistic renderings, see Figure 27.3. Computer software is also available to translate working and design drawings into machine instruction to aid in the production of the designed part.

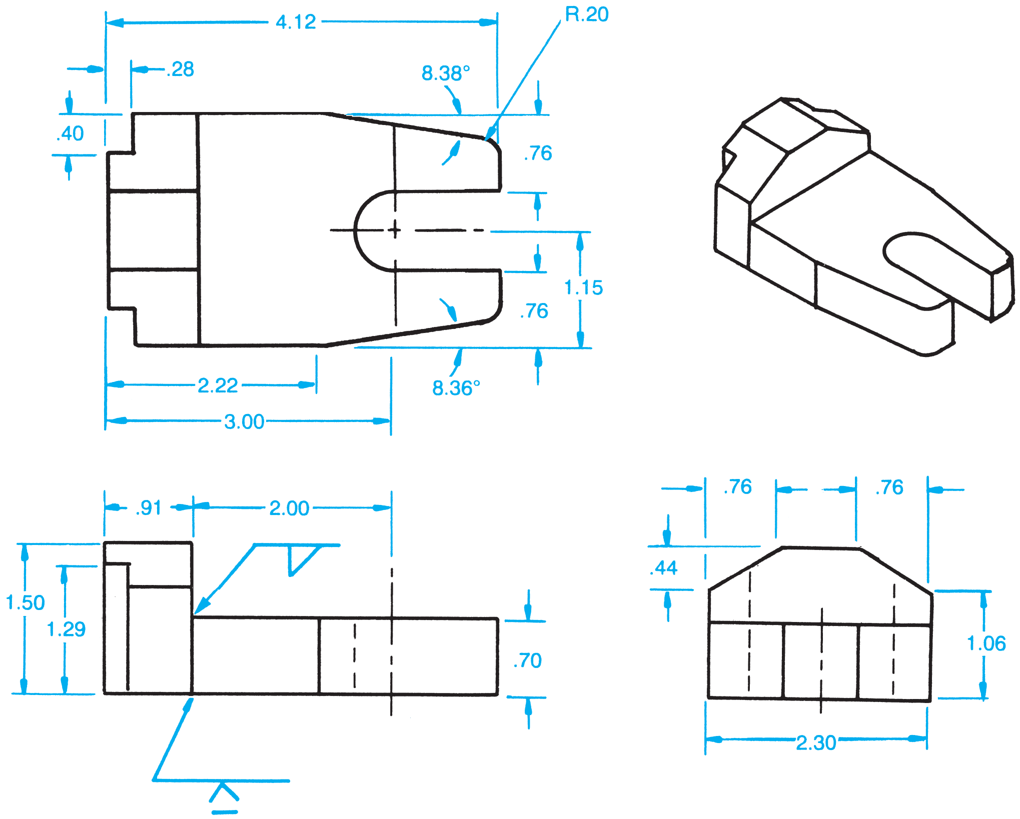


FIGURE 27.1 ■ Typical CAD drawing.

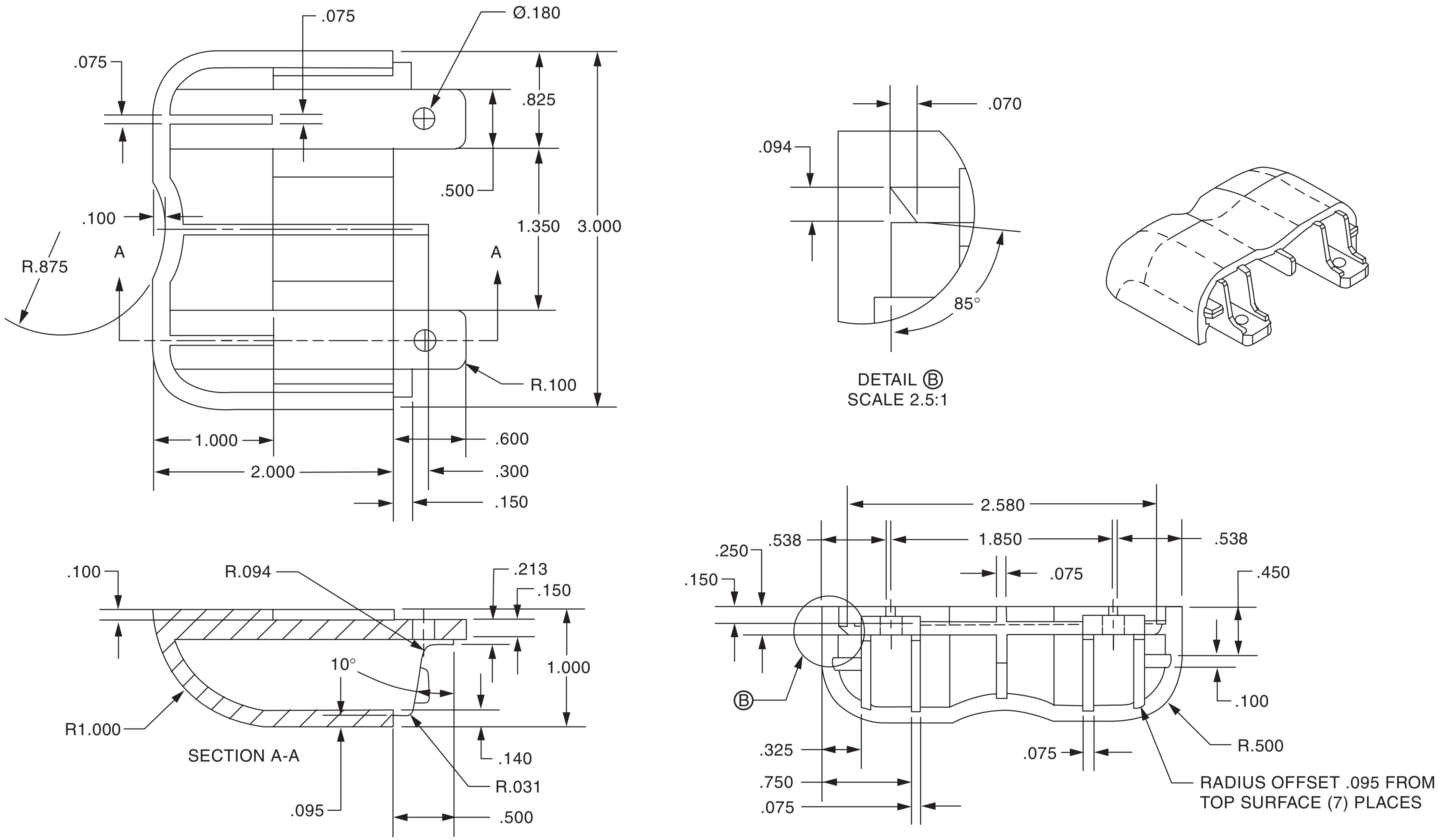


FIGURE 27.2 ■ Typical CAD drawing.

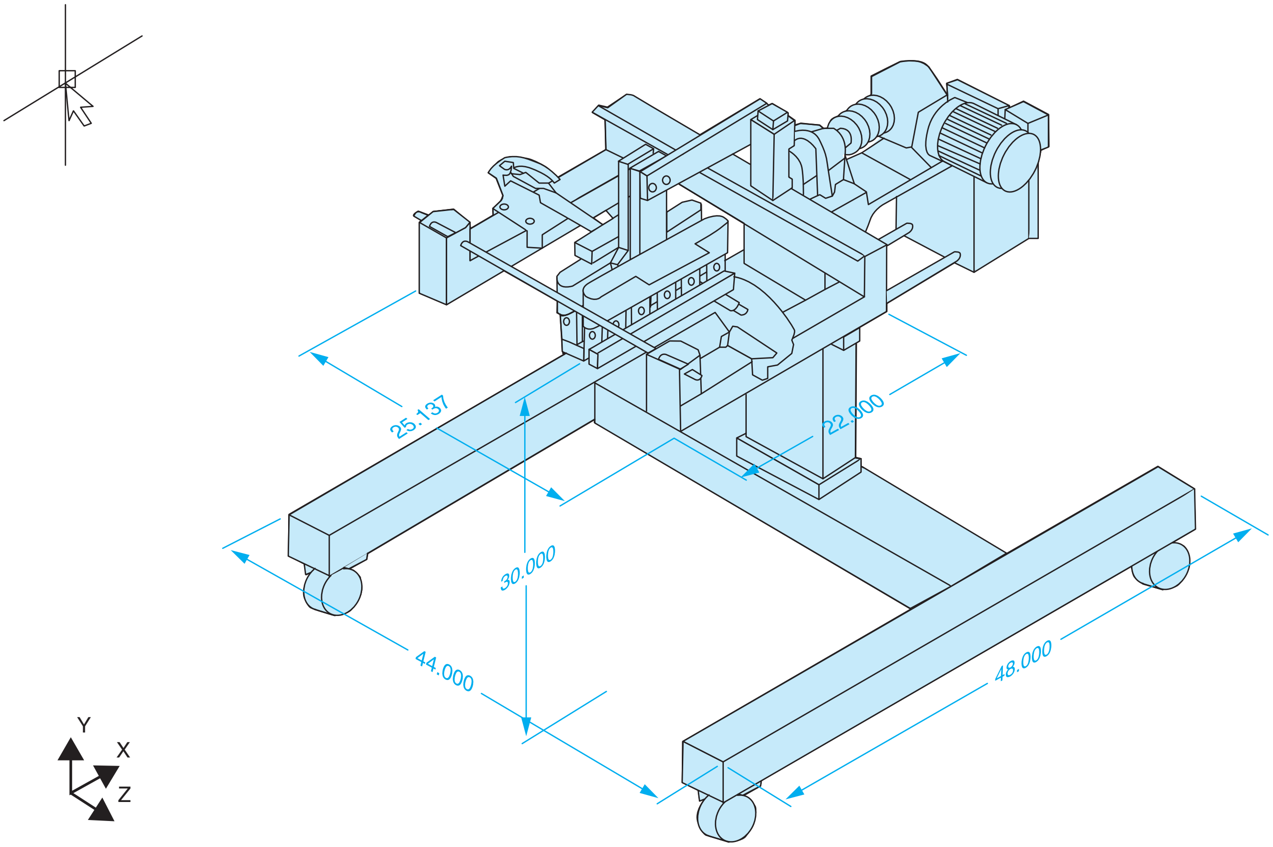


FIGURE 27.3 ■ Three-dimensional solid model.

Examples of computer programs that are used extensively in manufacturing are:

- Computer Assisted Machining (CAM)
- Computer Integrated Manufacturing (CIM)
- Computer Numerical Control (CNC)
- Computer Aided Design/Computer Aided Manufacturing (CAD/CAM)
- Computer Aided Drafting and Design (CADD)
- Computer Aided Drafting or Computer Aided Design (CAD)

The primary focus of this unit is to introduce the basics of Computer Aided Drafting (CAD).

Note that Figure 27.1 and Figure 27.2 include pictorial (isometric) drawings to assist in identifying the relationship of orthographic views to one another, thus expediting the interpretation of the drawings.

CAD programs provide the user with the ability to store and retrieve graphics and text information. The drawings produced by CAD can be used in a variety of different ways. For example, they can be used as an overlayment for detecting deficiencies and interference.

Three-dimensional drawings produced by CAD are often referred to as models. Models are often used to perform complex engineering stress analysis. In addition, three-dimensional models are often used to check tolerances and fits of complex assemblies. These capabilities, along with numerous others, have made this technology a welcomed addition to the engineering community. CAD has improved drawings standards and quality by allowing the user to build libraries of commonly used symbols and parts, thus allowing the user to merely insert these components instead of recreating them every time one is needed. CAD has improved the accuracy of engineering drawings. Most CAD drawings are created at a scale of 1:1 (full) and printed at the final desired scale.

These capabilities have not only decreased the amount of time required to produce and check engineering drawings, but have also improved the time required to design and manufacture parts and assemblies.

Models produced by CAD software can be loaded and analyzed by CAD/CAM programs to produce machine instruction for CNC (Computer Numeric Control) equipment, thus allowing for the production of part and components with minimal intervention by a machine operator.

COMPONENTS OF A CAD WORKSTATION

A computer workstation is where CAD drawings are produced. Basically, there are two main classifications of computers: mainframe and personal computers. Mainframe computers are used extensively by large corporations and governments for a variety of functions because of their speed and power. However, mainframes are extremely expensive and therefore are not effective and efficient solutions for smaller companies and organizations.

The personal computer has become the primary workhorse of the CAD community because of its size, cost of operation and maintenance, and speed.

Basically, a computer can be divided into two main categories: hardware and software. The hardware is made up of an assortment of electronic devices interconnected by electric cables, Figure 27.4. In short, hardware can be thought of as everything on a computer that can be physically touched. Software consists of the instructions used to make the computer's hardware work. It enables the operator to control the computer.

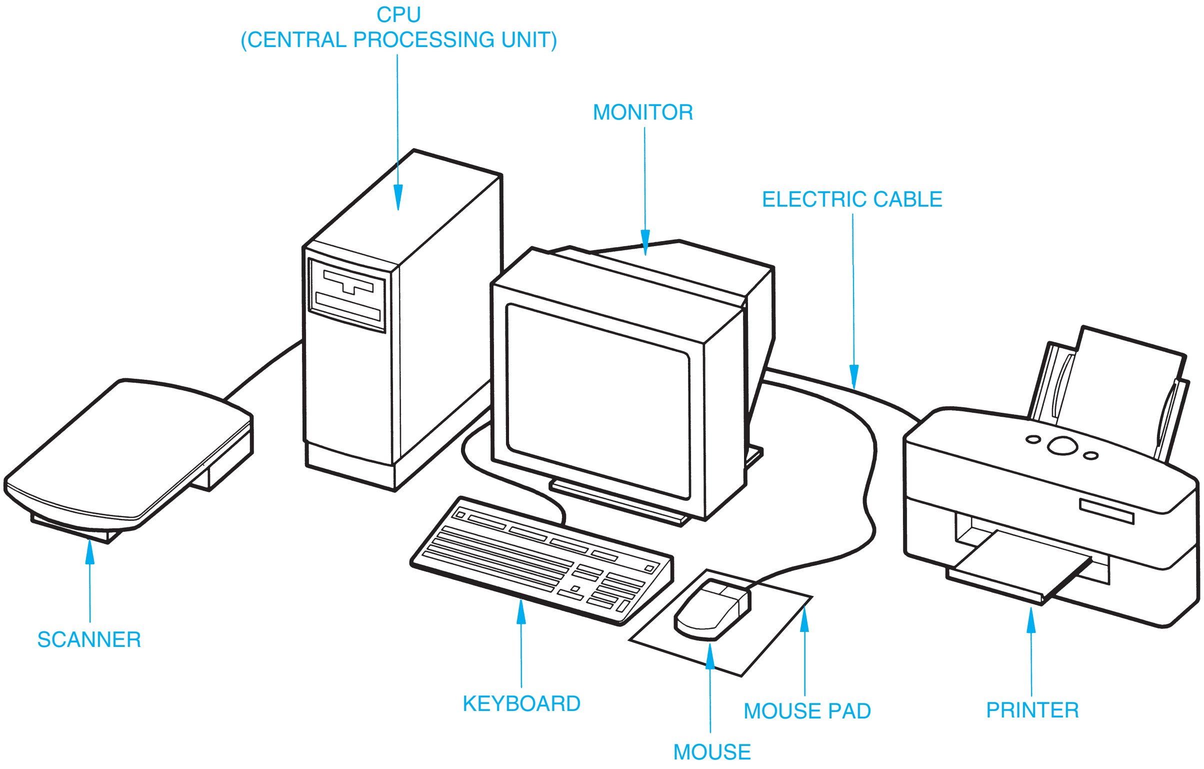


FIGURE 27.4 ■ Typical computer workstation.

HARDWARE COMPONENTS OF A CAD WORKSTATION

There are several key pieces of hardware that make up a CAD workstation. The first is the Central Processing Unit (CPU). The CPU is the heart of the computer; it controls the operation of the computer by performing arithmetic and logical operations and decodes and executes instructions provided by either the operator or a program. It is often commercially referred to as a tower or mini-tower.

Instructions from the user are entered into the computer using either a keyboard and/or a mouse. A keyboard, similar to a typewriter, allows the user to enter data and commands into the computer by pressing keys. The mouse is also an input device that can be used to enter data and/or commands into a computer by allowing the user to select items on the screen.

The monitor, resembling a television screen, provides visual graphic output to the operator. Monitors, like television, are also available in different sizes and configurations. A monitor can be either monochrome (displaying only two colors) or color. Information can also be entered into a computer using a scanner. A scanner is a device that reads text and/or illustrations that were printed on paper and translates it into a form that the computer can understand. A scanner works by placing an imaginary grid onto the image and then determining if the different areas of the grid are filled in or empty. While the scanner translates paper documents into a form the computer can understand, the printer takes information from the computer (text, illustrations, etc.) and prints them on paper. Although this is the minimal equipment necessary to produce a CAD drawing, other apparatus (peripheral devices) may also be incorporated into the workstation such as a stylus and plotter to produce large drawings.

CAD Software

CAD software is the most important component of the CAD workstation. Software by definition is anything that can be stored electronically. Typically, software is considered to be a program that controls and tells the computer to perform a specific function or set of functions. The output of a CAD program can be working and design drawings, technical data, piping, architectural and mechanical designs, or electrical and electronic circuitry. A variety of software programs are available for various purposes including auxiliary software to increase the efficiency of primary software. Examples of specific kinds of software are “AutoCAD,” “CADkey,” and “Microsotation.”

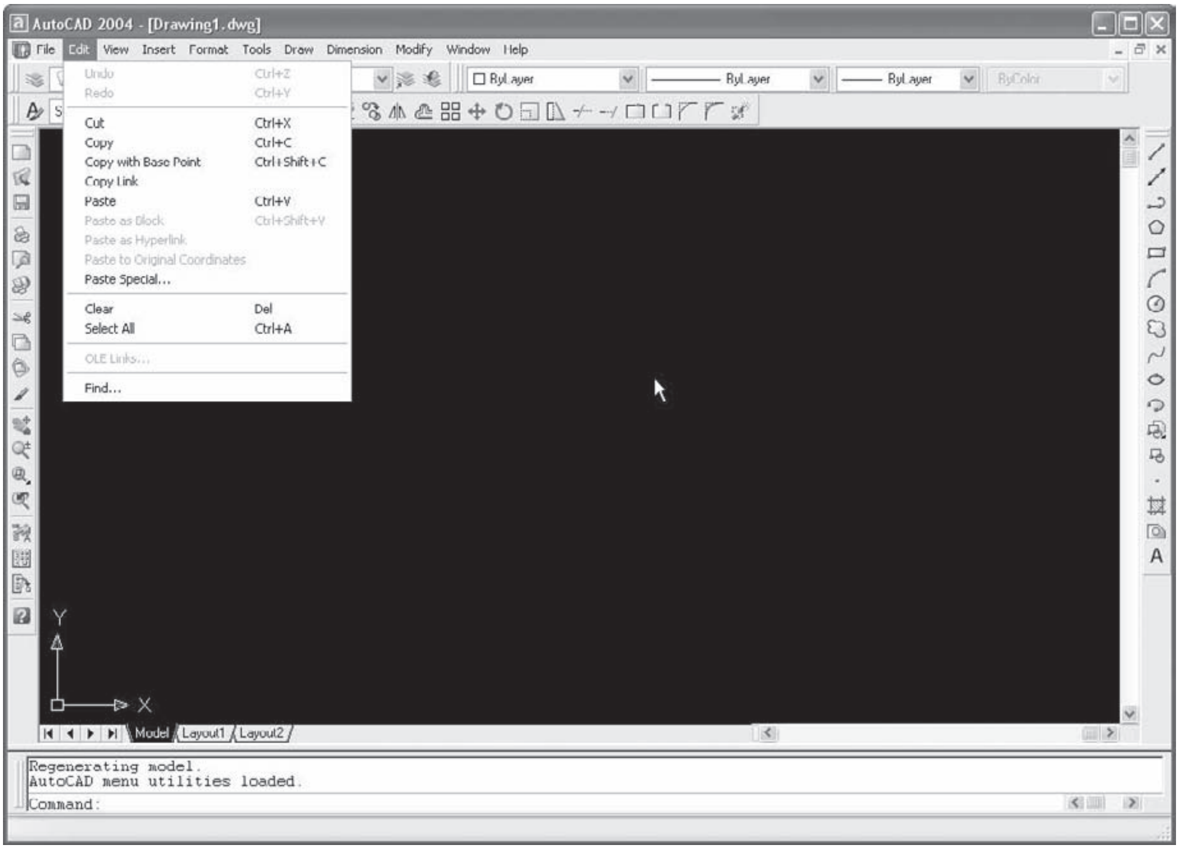
Typically, a CAD program will allow the user to enter information into the system either by selecting menu items or by typing commands. CAD menus are organized into categories such as geometric creations (lines, circles, arcs, etc.) and editing (erase, trim, extend, etc.). This enables the CAD operator to quickly select common and similar commands from a list, thus increasing the efficiency of creating a drawing. Examples of a CAD menu can be seen in Figure 27.5.

The selection of software items shown on the monitor screen is accomplished by using the cursor. A cursor is an indicator found on the screen that may be in the form of a small triangle, arrow, or some other similar configuration. Its purpose is to act as a pointer for selecting items on the screen for processing to the CPU. The cursor is moved by the operator by moving the mouse on the pad to select appropriate items for input to the CPU. Items may include lines, shapes, dimensions, and notes, as well as welding symbols.

To summarize, the computer operator uses a software program previously loaded onto the computer’s hard disc to create a drawing. The operator communicates to the CPU by means of a keyboard and mouse, selecting items from the menu shown on the monitor’s screen to formulate a drawing, notes, as well as welding symbols. The completed drawing shown on the monitor’s screen is sent to the printer for printing. The resulting output by the printer is a working or design drawing printed on paper which is referred to as hard copy. Typical CAD drawings are shown in Figure 27.1, Figure 27.2, and Figure 27.3. Note the regularity of the line weight, the precise intersections of lines, and the consistency of dimension lettering. Also note that in Figure 27.2 dimensions are shown in decimal fractions rather than common fractions. This has become the preferred practice for dimensioning a variety of drawings.

In conclusion, CAD is an extremely useful tool in the design and manufacturing process. Its output increases production, standardizes drawings, and generates data and a variety of drawings that may be electronically transferred to other computers.

Note: A glossary of computer terminology is found in Appendix 8.



```
Regenerating model.
AutoCAD menu utilities loaded.
Command:
```

FIGURE 27.5 ■ Example of a CAD menu.

UNIT 27: REVIEW A

1. Describe the difference between CAD and CADD.

____

____

____

2. List three different CAD packages that are currently available on the market today.

____

____

____

3. What are two advantages of using CAD over conventional manual drafting practices?

____

____

4. What is the difference between hardware and software?

____

____

5. List two output devices and input devices used at a computer workstation.
   a. Output device
      (1) ________________________________
      (2) ________________________________
   b. Input device
      (1) ________________________________
      (2) ________________________________

6. How does a monitor differ from a printer?

____

____

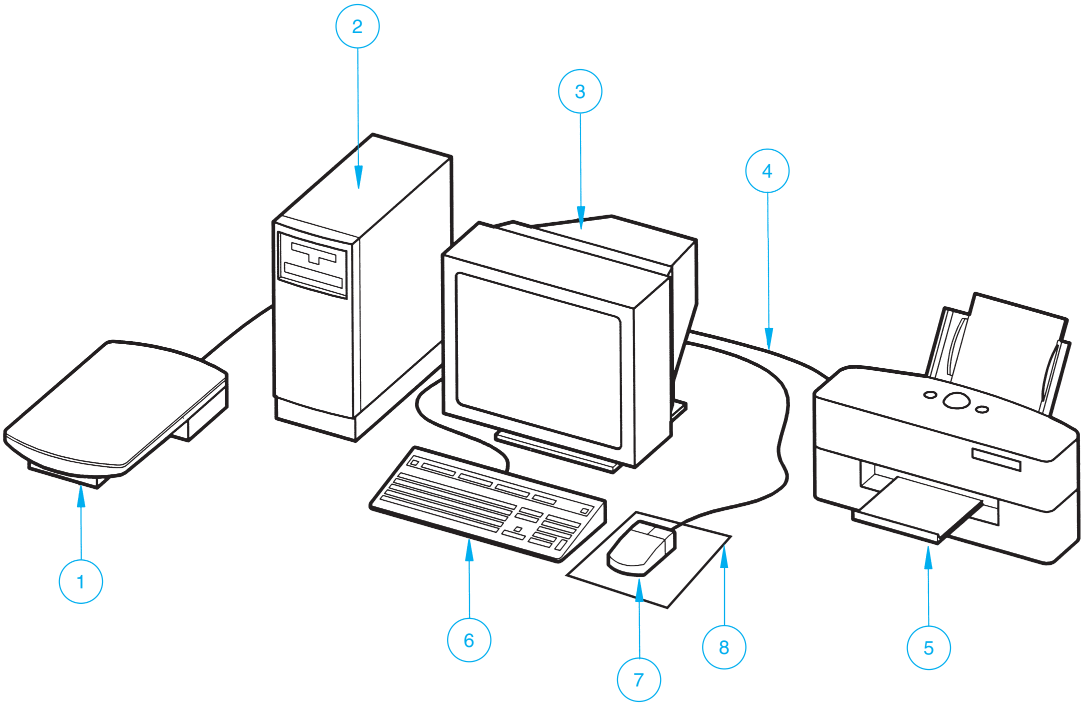
7. Information can generally be input into a CAD package using what two methods?

____

____

8. Define the following terms:
   a. CIM ________________________________
   b. CAM ________________________________

9. In the following illustration, (a) identify each component of the CAD workstation and (b) describe its function.



①

a.
b.

②

a.
b.

③

a.
b.

④

a.
b.

⑤

a.
b.

⑥

a.
b.

⑦

a.
b.

⑧

a.
b.

UNIT 27: REVIEW B

The following problems refer to foldout drawing number 7, Die Stand Frame.
Graph paper is provided at the end of this review for your use.

This die stand frame print is one that is actually used in industry. Some of the practices in dimensioning the prints and drawings of the views do not necessarily comply with standard dimensioning practices. In such cases, the company's standards were applied.

NOTE #1: In many instances, extension lines touch object lines in the dimensioning parts of this drawing. This is not standard practice. As a result, it is difficult to differentiate where extension and dimension lines begin and end. Furthermore, since all line weights are the same weight on CAD drawings, it significantly increases the difficulty of reading the print. In addition, extension and dimension lines cross object lines without a break, which, again, is not consistent with standard drafting practices.

NOTE #2: The drawing is zoned much like a travel map. Letters on the right edge of the drawing are for locating an approximate vertical location of a part. Numbers on the bottom edge are for locating the approximate horizontal location of a part. By crossing these locations (coordinates), an approximate location of a part can be found. The zoning process expedites the reading of a drawing print.

NOTE #3: The section drawing does not include section lines to show where the cutout of the part was made. Although this is not standard practice, companies may apply their own standards in the preparation of drawings. Eliminating a section lining reduces time in preparing drawings. However, section lining is the preferred practice for clarification purposes.

1. a. Sketch a welding symbol to illustrate the welds specified on the drawing including dimensions.
   b. List the applicable notes for the welds required including location of weld specified.

2. What type of drawing is illustrated?

3. Identify the views shown.

4. a. What is the significance of the symbol V shown on the drawing surfaces?
   b. What tolerance is to be applied?

5. a. List the specifications for the .750–10 UNC tapped holes.
   b. Interpret .750–10 UNC.

6. a. Describe part ⑫.
   b. In what zone is it located on the drawing?

7. a. Prepare a two-view orthographic sketch of item ⑦.
   b. Place a note on the sketch specifying the kind of material that is to be used.

8. What is the significance of dimensions enclosed in parentheses?

9. The dimensions that follow, as found on the drawing, are incorrect in accordance with drafting standards. Sketch correct versions.

Incorrect
1.50 R

2.0 R

2.032 Drill

1.0 R

10. a. What kind of material is specified for item ③?

    b. List its size and quantity required.

11. What type of material and its size is specified for item ⑩?

12. What style of numerical dimensioning is used?

13. What is the purpose of identifying the zone locations for each item?

14. Prepare an isometric sketch of part ① and dimension it.

15. Prepare a two-view orthographic sketch of part ④ and dimension it.

16. a. In what zone is part ⑫?

    b. Prepare a two-view orthographic sketch and dimension it.

17. a. What quantity is required for part ①?

    b. What material is to be used?

18. Identify the kind of drawing showing parts ①, ②, ④, ⑤, and ⑫.

①

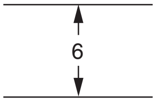
②

④

⑤

⑫

19. What is the purpose of the dimension shown on the left edge of the drawing as follows?



20. What scale size is used for this drawing?

21. What is the overall size of the “Die Stand Frame”?

22. List the dimensions for part ⑧.

23. What is the angular spacing of holes shown equally spaced on a 14.500 ∅ ?

24. What is the ream size specified for the two holes after completion of welding?

25. How many pieces are required for making the “Die Stand Frame”?

26. What is the center-to-center spacing between parts ⑨?

27. a. What is the spacing size between the rectangular steel tubing?

    b. What are the hole sizes for part ⑨?

28. a. How many flame-cut holes are to be made?

    b. Identify the item(s) to have a flame-cut hole.

29. Where extension lines connect to object lines, make a red check to indicate where there should be a break.

30. Where dimension lines do not show a break when crossing object lines, make a red check mark to indicate where breaks should be made.

31. Add section lining to show where the rectangular tubing has been cut. Select the appropriate view to show this. Also, section lines should represent the kind of material for these parts.

32. Which dimension(s) found on the drawing is/are shown as a common fraction?

____

33. What is the significance of A/R?

____

UNIT 28

Introduction to Geometric Dimensioning and Tolerancing

This unit will focus on selected fundamental symbols and terms for reading geometric dimensioning and tolerancing (GDT) drawings. The content is limited to the extent that is required for reading foldout drawing #8, Roller Stand Weldment. Additional study will be necessary for reading more complex drawings.

Geometric dimensioning and tolerancing is the most current standard for dimensioning orthographic drawings. The majority of manufacturing companies, including the military, have adopted this standard.

There are similarities between the **coordinate** and **GDT standards**; however, GDT incorporates the use of special geometric symbols, modifiers, and terms not found on coordinate dimensioned drawings.

A listing of the most common symbols in GDT dimensioning is found in Figure 28.1. These are identified as **Geometric Characteristic Symbols.**

In addition to geometric symbols, a set of symbols identified as **Geometric Symbol Modifiers** are used in conjunction with geometric characteristic symbols, Figure 28.2.

CHARACTERISTIC	SYMBOL
FLATNESS	⏥
STRAIGHTNESS	—
CIRCULARITY	○
CYLINDRICITY	⌭
PERPENDICULARITY	⊥
ANGULARITY	∠
PARALLELISM	//
POSITION	⌖
CONCENTRICITY	◎
CIRCULAR RUNOUT	↗
TOTAL RUNOUT	⌰
PROFILE OF A LINE	⌒
PROFILE OF A SURFACE	⌓

FIGURE 28.1 ■ Geometric characteristic symbols.

TERM	SYMBOL
DIAMETER	Ø
SPHERICAL DIA	SØ
MAXIMUM MATERIAL COND	Ⓜ
LEAST MATERIAL COND	Ⓛ
PROJECTED TOLERANCE ZONE	Ⓟ
FREE STATE	Ⓕ
TANGENT PLANE	Ⓣ
STATISTICAL TOLERANCE	⟨ST⟩
REGARDLESS OF FEATURE SIZE	Ⓢ

FIGURE 28.2 ■ Geometric modifier symbols.

Feature control frames are used to contain geometric characteristic symbols, geometric symbol modifiers, and other special symbols related to GDT dimensioning. Typical feature control frames with geometric characteristic symbols are illustrated in Figure 28.3 and Figure 28.4.

The first item contained within a feature control frame is always a geometric characteristic symbol. Not more than one such symbol is shown within a frame, Figure 28.3. The number and size of compartments within a frame will vary depending upon the extent of data to be specified. Also, any additional data to be included in the compartments that follow are shown in accordance with a national standard that specifies the sequence to be followed.

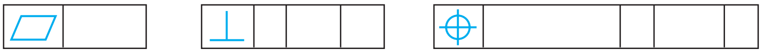


FIGURE 28.3 ■ Examples of feature control frames.

When required, a geometric symbol modifier is the second item included in a feature control frame. It refers to the geometric characteristic symbol that precedes it. Note: Modifiers are not used for the following geometric characteristic symbols:

Straightness ⏤

Flatness ⏥

Circularity ○

Cylindricity ⌭

In such cases, the second item shown in the frame is a tolerance value.

Geometric characteristic symbols requiring the use of a modifier are as follows:

perpendicularity ⟂

parallelism //

circular runout ↗

total runout ⌰

profile of a line ⌒

profile of a surface ⌓

position ⌖

concentricity ◎

symmetry ⌯

Figure 28.4 illustrates examples of data contained within a feature control frame with the proper sequence of data. Note that all dimensions using Feature Control Frames are in decimal fractions. This also applies to all dimensions shown in a GDT drawing, with some exceptions. For example, size dimensions for welding symbols are shown as common fractions as well as dimensions for stock items such as steel angle: 2½ × 2½ × 3⁄16.

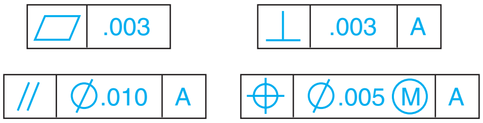


FIGURE 28.4 ■ Feature control frames.

The basic sequence of items in a feature control frame is also illustrated in Figure 28.5. Other items may be added to the frame for special purposes; however, they are not included in this abbreviated study.

At this point, it is important to understand the concept of a **feature.** There are several applications of the word "feature." Refer to Figure 28.6.

- **Feature**: a term applied to a part such as a surface, slot, or hole.
- **Feature of size**: a size dimension applied to a part that may be a circle, sphere, angle, or distance between two or more parallel surfaces.
- **Feature of location**: a size dimension that locates the centerlines of a circle or a centerline of a part in relation to another part. Refer to Figure 28.6 for an example of each kind of feature.
- **Datum feature**: any feature of a part such as a surface, plane, or hole.

Feature control frames are applied to drawing parts and dimensions in a number of ways. Figure 28.7 illustrates several examples of how frames are applied Their purpose is to refine the dimensioning of parts on a drawing in order to produce a more acceptable and economical product.

A **datum** feature symbol is another special symbol used in GDT drawings. This symbol is illustrated in Figure 28.8.

Note that the original symbol identified as obsolete has been replaced by a preferred (current) symbol; however, many drawings will have the obsolete symbol as shown in Figure 28.8.

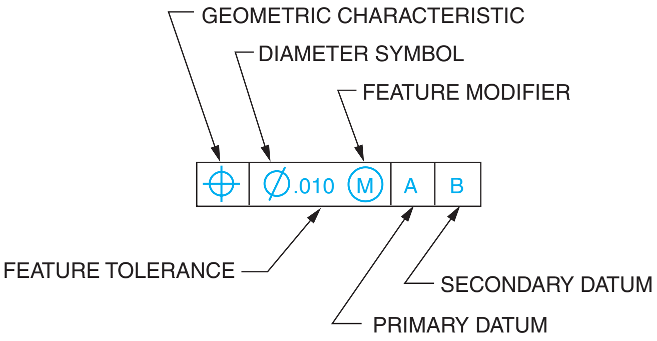


FIGURE 28.5 ■ Standard sequence of items in a feature control frame.

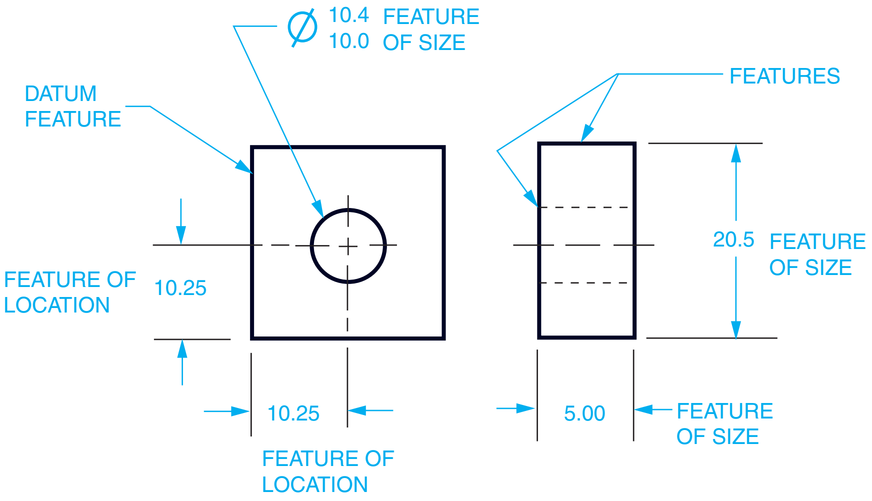


FIGURE 28.6 ■ Identification of kinds of features.

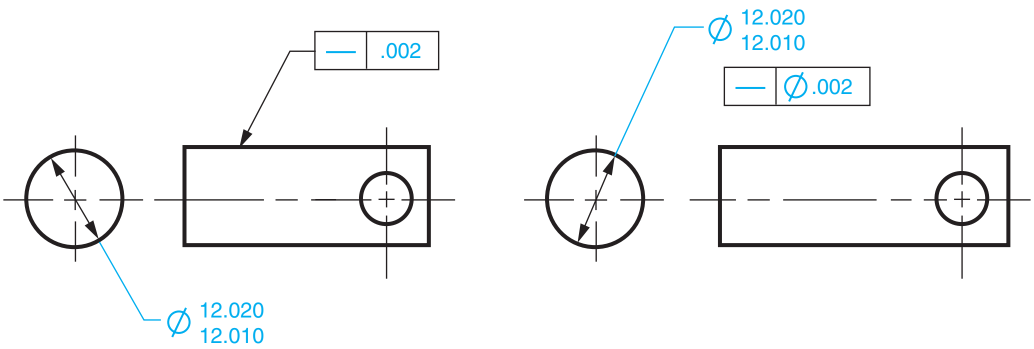


FIGURE 28.7 ■ Application of feature control frames to a part.

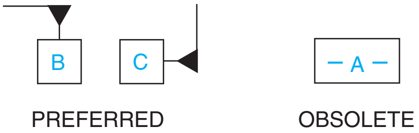


FIGURE 28.8 ■ Examples of datum feature symbol locations.

The letter contained within a datum feature on a drawing may have reference to a surface dimension or any other feature that makes up the drawing. The datum feature symbol may be attached to an extension line or attached to a feature control frame Figure 28.9.

Another important concept to be understood for interpreting a GDT drawing is the reference to the size of an item on the drawing shown within a feature control frame—least material condition shown by the symbol Ⓛ, and maximum material condition shown by the symbol Ⓜ. Figure 28.10(a) illustrates the significance of each of these symbols. Note that least material condition (LMC) refers to a part when its material content is produced at its lower size limit, and maximum material condition (MMC) refers to the condition of a part when its material content is produced at its upper size limit.

Figure 28.10(b) is another example that illustrates the concept of maximum and least material conditions of a part. Note that when there is a hole in the part, the part is at MMC when the dimension is at its lowest limit, and at LMC when the hole is at its upper limit.

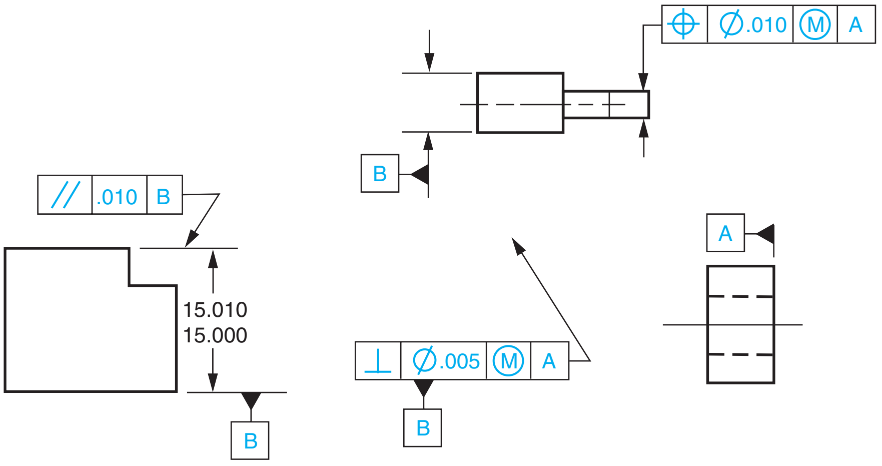
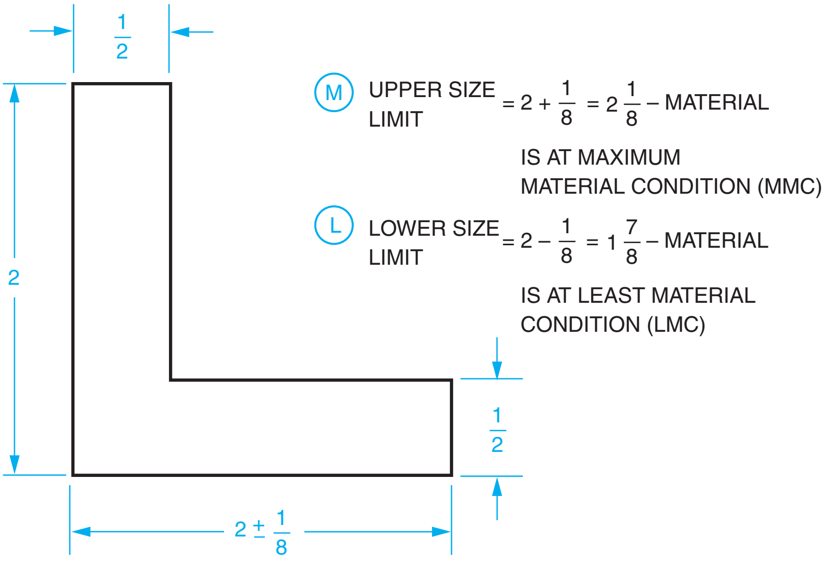


FIGURE 28.9 ■ Examples of locations of a datum feature symbol.



1/2
2
2 ± 1/8
1/2
Ⓜ UPPER SIZE LIMIT = 2 + 1/8 = 2 1/8 – MATERIAL
IS AT MAXIMUM MATERIAL CONDITION (MMC)
Ⓛ LOWER SIZE LIMIT = 2 – 1/8 = 1 7/8 – MATERIAL
IS AT LEAST MATERIAL CONDITION (LMC)

FIGURE 28.10(a) ■ Maximum and least material conditions of a part.

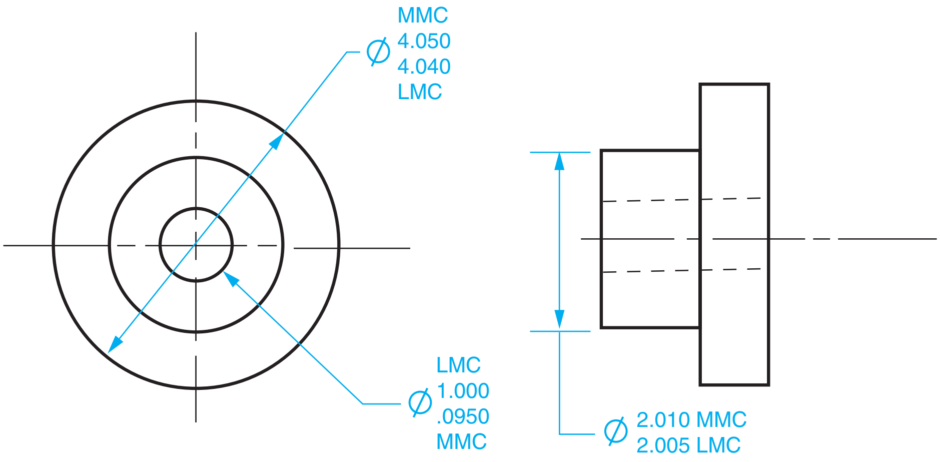


FIGURE 28.10(b) ■ Additional examples of maximum and least material conditions of a part.

Other items found on GDT drawings that are also common to coordinate drawings are as follows:

- A dimension enclosed in a square $\boxed{2.02}$ is identified as a **basic dimension**. It is considered to be an exact dimension to which tolerance values are applied.
- A dimension enclosed in parenthesis (3.02) is identified as a **reference dimension**. It is not a required dimension. However, it may be included to expedite reading a drawing without the need for addition or subtraction of dimensions to obtain a size.
- An all-around ⌀ is used to indicate the dimension that applies to all around the feature, just as a similar symbol in welding indicates to weld-all-around.
- □ symbol for indicating a square.
- ⌴ symbol for indicating a counterbore or spotface.
- ⌵ symbol for indicating a countersink.
- ↧ symbol for indicating depth.
- X symbol for number of places; for example, 6X.

The illustration that follows (Figure 28.11) is an example of GDT dimensioning and the interpretation of the feature control frames used.

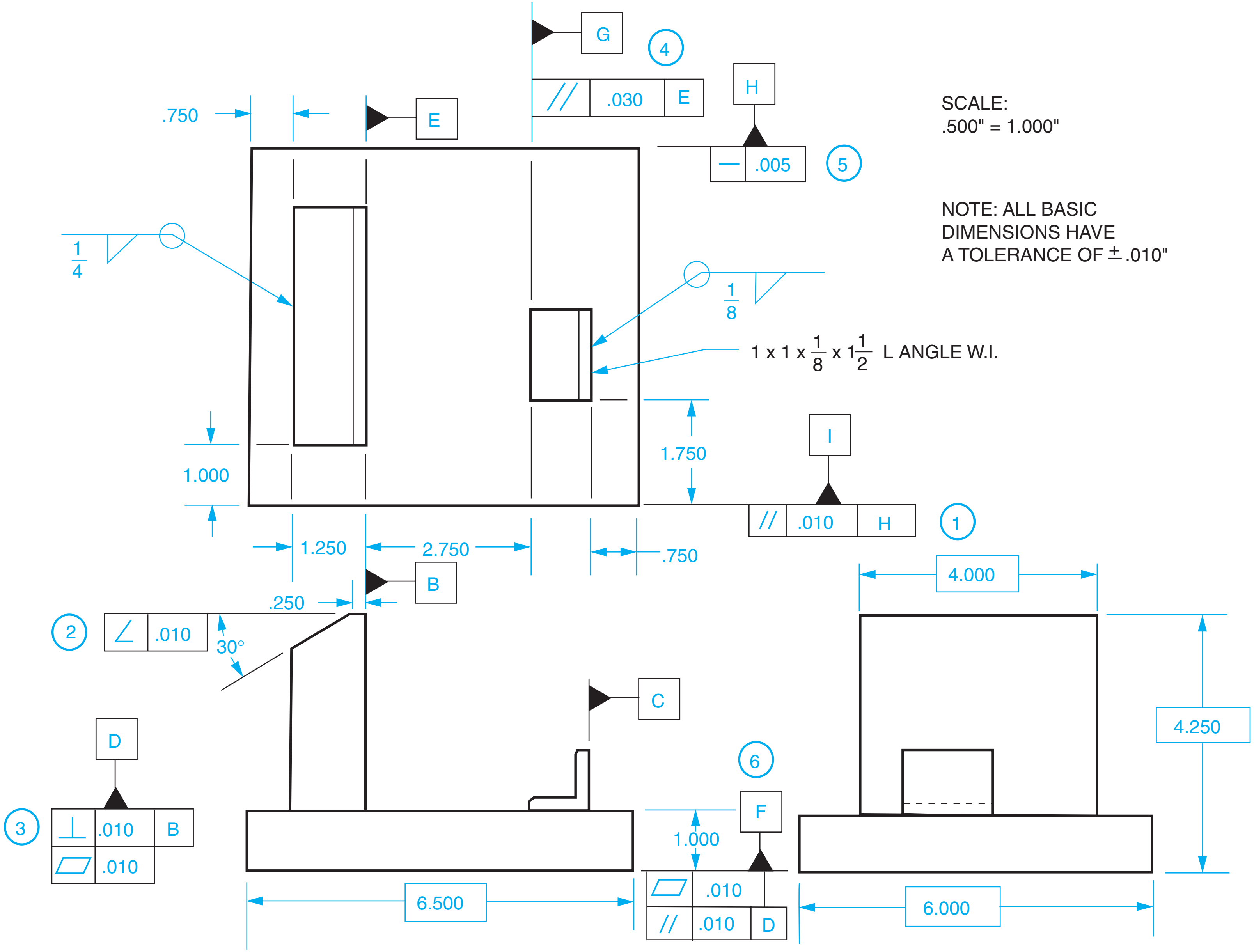
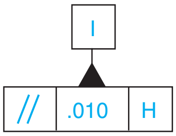
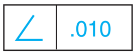
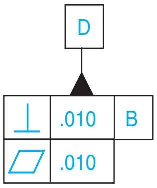
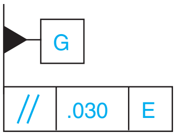
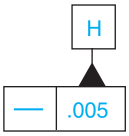
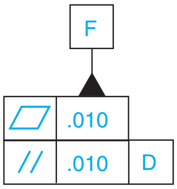


FIGURE 28.11 ■ Application of feature control frames.

Note that in the significance column, reference is made to the term tolerance zone. The standard definition for this term is: “It is a boundary established by a size or geometric tolerance in which the actual feature must stay within.” A further study of the interpretation of this term as well as an extended study of GDT elements can be found in Cengage Learning’s publication entitled, *Fundamentals of Geometric Dimensioning and Tolerancing* by Alex Krulikowski. Foldout drawing #10, Strongback Stand, is provided at the back of this book for continued study of GDT.

Feature Control Frames	**Significance**
① 	Datum I to be parallel to Datum H within a tolerance zone of .010 inch.
② 	30° angle to be within a tolerance zone of .010 inch.
③ 	Upper frame: Datum D to be perpendicular to Datum B within tolerance zone of .010 inch. Lower frame: Datum D to have a flat surface within a tolerance zone of .010 inch.
④ 	Datum G to be parallel to Datum E within a tolerance zone of .030 inch.
⑤ 	Datum H to be straight within a tolerance zone of .005 inch.
⑥ 	Upper frame: Datum F surface to be flat within a tolerance zone of .010 inch. Lower frame: Datum F to be parallel to Datum D within a tolerance zone of .010 inch.

UNIT 28: REVIEW A

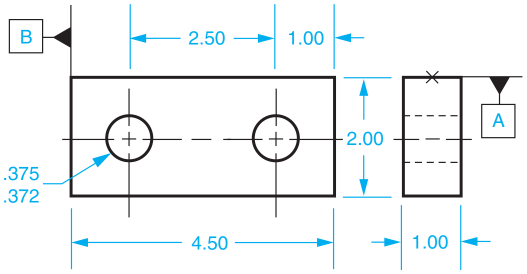
Graph paper is provided at the end of this review for your use.

1. Sketch the geometric characteristic symbols for the following:
   - a. Parallelism
   - b. Circularity
   - c. Straightness
   - d. Profile of a line
   - e. Perpendicularity
   - f. Angularity
   - g. Flatness
2. Interpret the following symbols.
   - a. Ⓛ ______________________________
   - b. ⌀ ______________________________
   - c. Ⓜ ______________________________
   - d. Ⓢ⌀ ______________________________
3. Identify the geometric characteristic symbols that do not require a modifier.

   ____

   ____
4. Sketch three geometric characteristic symbols requiring a geometric symbol modifier.
5. Sketch a feature control frame symbol showing a geometric characteristic symbol with a flatness tolerance value of .020.
6. What type of dimensioning must be used in a control frame?

   ____
7. Sketch a feature control frame symbol that includes a geometric characteristic symbol for position, a diameter symbol with a tolerance value of .015, a maximum material condition symbol, and datum reference with the letter B.
8. a. In the sketch that follows, identify a feature, a feature of size, a feature of location, and a datum feature.



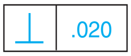
   ____

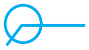
   ____

   ____

   ____

   b. Add a feature control frame to the surface indicated by an X that will indicate the flatness of a feature with a .005 tolerance value.
9. a. Complete what is missing in the following datum feature symbol.

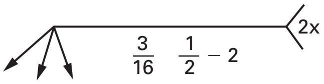


   b. Sketch the obsolete symbol for a datum feature symbol.
10. What is the significance of the following symbols with reference to GDT drawings?
   - a. $\boxed{2.0}$ ______________________________
   - b. ∨ ______________________________
   - c. ⓧ ______________________________
   - d. □ ______________________________
   - e. ↧ ______________________________
   - f. ⌴ ______________________________
   - g.  ______________________________

UNIT 28: REVIEW B

Note: The following questions refer to foldout drawing #8, Roller Stand Weldment.

1. List the dimension tolerances for the stand.
   a. Decimal
   b. Fractional
   c. Angular
2. Give the revision record for the drawing.
3. Sketch two reference dimensions found on the drawing that are outdated methods for indicating a reference.
4. Sketch each of the welding symbols found on the drawing and interpret each.
5. What is the significance of the following dimension as shown on the symbol that follows?



6. List the various materials that are stock items for making the stand. Include the dimensions for each.
7. What is the significance of each of the feature control frames that follow?
   a. | // | .010 | A |
   b. | ⊥ | .010 | C |
8. Interpret the tolerances specified in the title box:
   a. decimal ±.xx
   b. decimal ±xxx
   c. angular ±3
9. a. What is the purpose of the breaklines shown on the print?
   b. On what number part(s) are they located?
   c. On which view(s) are they shown?
10. List the material required to make the weldment stand, and the number required of each.
11. a. What is the overall size of the weldment stand?
    b. How many welds are required?
    c. List the kinds of welds required.

12. a. List the size of part (06) including length.

b. Which of these dimension(s) is approximate?

13. a. Identify the part that revision "A" refers to.

b. What was the original data specified?

14. a. What size is specified for the steel angel part (03)? ________________

b. What is the overall length required?

15. Interpret the significance of the following dimensions.

a. 3.00 Ref.

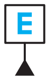
b. $\frac{16.53}{16.47}$

16. a. Sketch the welding symbols applicable to part (03).

b. Interpret each element found on these symbols.

17. What is the rectangle that encloses the GDT data referred to as?

18. What is the purpose of the following GDT symbol?



____

19. What is the size of the rectangular steel tubing component?

20. a. On what parts by number are chamfers specified?

b. What angle(s) are specified for each?

21. a. Identify the views shown on the drawing.

b. Identify the locations of the broken-out enlarged detail views.

c. What is the purpose of these views?

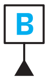
22. What are the maximum and minimum dimensions for the following?

a. R.750 max.________min.________

b. 15.25 max.________min.________

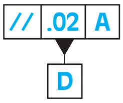
23. Interpret the following GDT symbols.

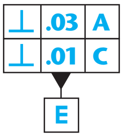
a.

b. 

c. Which symbol has replaced the other as the most current symbol?

24. Interpret the following GDT symbols.

a. 

b. 

25. a. Sketch the welding symbol for joining the part (01) to part (04).

b. Interpret the symbol.

26. a. Sketch the welding symbol for joining part 03 to part 04.
    b. Interpret the symbol.

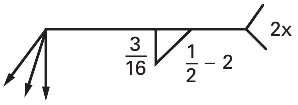
27. a. Sketch the welding symbols for joining part 05 to part 04.
    b. Interpret each welding symbol.

28. a. Sketch the symbol for joining part 05 to part 06.
    b. Interpret the symbol.

29. Sketch the joint configuration for welding part 04 to part 05.

30. a. What tolerance(s) is applicable to the R.750 dimension?
    b. In how many places?

31. What is the purpose for using three arrow lines for the symbol shown on the print as follows:



32. Identify whether the print is first-angle or third-angle projection, a multiple or detail assembly print, or both a multiple detail and assembly print.

33. Which part requires a surface finish?

34. Sketch the welding symbol on the print that specifies a convex surface finish.

35. a. What is the difference between a weld symbol and a welding symbol?
    b. Sketch a welding symbol with multiple reference lines.
    c. What is the purpose of the multiple reference lines?
    d. Are multiple reference lines applicable to any of the symbols shown on the print?

36. a. What is the total length of the fillet welds required to assemble all of the pieces?
    b. What is the total length of the flare-bevel weld for assembling the pieces?

UNIT 28: REVIEW C

Note: The following questions refer to foldout drawing #10, Strongback Stand.

1. What is the significance of the following symbols?
   a. 2x 5.00″
   b. 6X
      ∅ .562″ THRU
      ∅ ∅.03
   c. (10.12″)
   d. 2X
      9.00″ ±.12
   e. (R1.015)
2. a. List the kinds of welds shown on the print.

b. Which symbol indicates an other side weld?

____

3. What radius is specified for all edges of the tubing? ______________________

4. What angular tolerance is specified for all chamfers? ______________________

____

5. Identify the dimensions to which a .06 tolerance is applied. ______________________

____

6. What tolerance is applied to the six drilled holes on the steel angle pieces? ____________

7. Prepare a sketch showing the location dimensions for the drilled holes on the steel angle pieces.

8. What is the significance of the following symbol? ⌓ .005 A B

____

9 a. Are any revisions specified on the drawing?

____

b. Is provision provided on the drawing to list revisions? ______________________

10. What is the significance of the following dimension? 24.00″ (REF.) ______________________

____

11. What is the size indicate by the following welding symbol? ______________________

____

12. a. Interpret the following dimension(s).

8X
.50″ × 45° CHAMFER

____

____

b. 2X
∅.781″ THRU.

____

____

13. a. Prepare a simple sketch to show the location dimensions for the drilled holes in the tubing.

b. What tolerance size is applicable to the drilled holes? ______________________

14. Prepare a sketch with dimensions to show the chamfers required on the steel angles.

15. Prepare a sketch with dimensions to show the chamfers required at each end of the tubing including tolerances where applicable.

16. a. What size of steel angle material is required?

____

b. How many angle pieces?

____

17. List the total length of the strongback stand.

____

18. What is the inside size of the tubing? Add the symbol for indicating an approximate size.

____

19. What is the spacing of the drilled holes between each end of the tubing?

____

20. How many inches of weld is required for each steel angle? ______________________

21. Sketch the shape of the joints of the steel angle to be welded.

22. a. Identify the location of the surface(s) requiring a finish.

____

____

b. List the dimension(s) applicable to the finish.

____

23. Identify the dimension(s) which has a + tolerance to three decimal places. ______________________

____

24. List the common fraction dimensions shown on the print and the items to which these tolerances apply.

____

____

____

____

25. a. With reference to the line weight(s) used on the drawing, identify the method for producing it. ______________________

b. Give the reason for your answer.

____

____

____

APPENDICES

APPENDIX 1

TABLES

TABLE 1 INCHES TO MILLIMETERS

in.	mm	in.	mm	in.	mm	in.	mm
1	25.4	26	660.4	51	1295.4	76	1930.4
2	50.8	27	685.8	52	1320.8	77	1955.8
3	76.2	28	711.2	53	1346.2	78	1981.2
4	101.6	29	736.6	54	1371.6	79	2006.6
5	127.0	30	762.0	55	1397.0	80	2032.0
6	152.4	31	787.4	56	1422.4	81	2057.4
7	177.8	32	812.8	57	1447.8	82	2082.8
8	203.2	33	838.2	58	1473.2	83	2108.2
9	228.6	34	863.6	59	1498.6	84	2133.6
10	254.0	35	889.0	60	1524.0	85	2159.0
11	279.4	36	914.4	61	1549.4	86	2184.4
12	304.8	37	939.8	62	1574.8	87	2209.8
13	330.2	38	965.2	63	1600.2	88	2235.2
14	355.6	39	990.6	64	1625.6	89	2260.6
15	381.0	40	1016.0	65	1651.0	90	2286.0
16	406.4	41	1041.4	66	1676.4	91	2311.4
17	431.8	42	1066.8	67	1701.8	92	2336.8
18	457.2	43	1092.2	68	1727.2	93	2362.2
19	482.6	44	1117.6	69	1752.6	94	2387.6
20	508.0	45	1143.0	70	1778.0	95	2413.0
21	533.4	46	1168.4	71	1803.4	96	2438.4
22	558.8	47	1193.8	72	1828.8	97	2463.8
23	584.2	48	1219.2	73	1854.2	98	2489.2
24	609.6	49	1244.6	74	1879.6	99	2514.6
25	635.0	50	1270.0	75	1905.0	100	2540.0

The above table is exact on the basis: 1 in. = 25.4 mm.

TABLE 2 CONVERSION OF INCHES TO MILLIMETERS

	mm									
in.	0	1	2	3	4	5	6	7	8	9
0		25.4	50.8	76.2	101.6	127.0	152.4	177.8	203.2	228.6
10	254.0	279.4	304.8	330.2	355.6	381.0	406.4	431.8	457.2	482.6
20	508.0	533.4	558.8	584.2	609.6	635.0	660.4	685.8	711.2	736.6
30	762.0	787.4	812.8	838.2	863.6	889.0	914.4	939.8	965.2	990.6
40	1016.0	1041.4	1066.8	1092.2	1117.6	1143.0	1168.4	1193.8	1219.2	1244.6
50	1270.0	1295.4	1320.8	1346.2	1371.6	1397.0	1422.4	1447.8	1473.8	1498.6
60	1524.0	1549.4	1574.8	1600.2	1625.6	1651.0	1676.4	1701.8	1727.2	1752.6
70	1778.0	1803.4	1828.8	1854.2	1879.6	1905.0	1930.4	1955.8	1981.2	2006.6
80	2032.0	2057.4	2082.8	2108.2	2133.6	2159.0	2184.4	2209.8	2235.2	2260.6
90	2286.0	2311.4	2336.8	2362.2	2387.6	2413.0	2438.4	2463.8	2489.2	2514.6
100	2540.0	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .

All values in this table are exact, based on the relation 1 in. = 25.4 mm. By manipulation of the decimal point, any decimal value or multiple of an inch may be converted to its exact equivalent in millimeters.

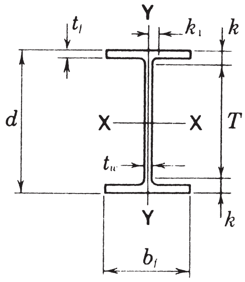
Example for using Table 2:
To convert 36 inches to millimeters (mm) refer to in. column
30 in. = 762 mm
6 in. = $\underline{+152.4}$ mm
Total: 914.4 mm

TABLE 3 INCH/METRIC EQUIVALENTS

Fraction	Decimal Equivalent		Fraction	Decimal Equivalent	
	Customary (in.)	Metric (mm)		Customary (in.)	Metric (mm)
1/64	.015625	0.3969	33/64	.515625	13.0969
1/32	.03125	0.7938	17/32	.53125	13.4938
3/64	.046875	1.1906	35/64	.546875	13.8906
1/16	.0625	1.5875	9/16	.5625	14.2875
5/64	.078125	1.9844	37/64	.578125	14.6844
3/32	.09375	2.3813	19/32	.59375	15.0813
7/64	.109375	2.7781	39/64	.609375	15.4781
1/8	.1250	3.1750	5/8	.6250	15.8750
9/64	.140625	3.5719	41/64	.640625	16.2719
5/32	.15625	3.9688	21/32	.65625	16.6688
11/64	.171875	4.3656	43/64	.671875	17.0656
3/16	.1875	4.7625	11/16	.6875	17.4625
13/64	.203125	5.1594	45/64	.703125	17.8594
7/32	.21875	5.5563	23/32	.71875	18.2563
15/64	.234375	5.9531	47/64	.734375	18.6531
1/4	.250	6.3500	3/4	.750	19.0500
17/64	.265625	6.7469	49/64	.765625	19.4469
9/32	.28125	7.1438	25/32	.78125	19.8438
19/64	.296875	7.5406	51/64	.796875	20.2406
5/16	.3125	7.9375	13/16	.8125	20.6375
21/64	.328125	8.3384	53/64	.828125	21.0344
11/32	.34375	8.7313	27/32	.84375	21.4313
23/64	.359375	9.1281	55/64	.859375	21.8281
3/8	.3750	9.5250	7/8	.8750	22.2250
25/64	.390625	9.9219	57/64	.890625	22.6219
13/32	.40625	10.3188	29/32	.90625	23.0188
27/64	.421875	10.7156	59/64	.921875	23.4156
7/16	.4375	11.1125	15/16	.9375	23.8125
29/64	.453125	11.5094	61/64	.953125	24.2094
15/32	.46875	11.9063	31/32	.96875	24.6063
31/64	.484375	12.3031	63/64	.984375	25.0031
1/2	.500	12.7000	1	1.000	25.4000

APPENDIX 2

STRUCTURAL METAL SHAPE DESIGNATIONS



W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
W 36×300	88.3	36.74	36¾	0.945	15/16	½	16.655	16⅝	1.680	1 11/16	31⅛	2 13/16	1½
×280	82.4	36.52	36½	0.885	⅞	7/16	16.595	16⅝	1.570	1 9/16	31⅛	2 11/16	1½
×260	76.5	36.26	36¼	0.840	13/16	7/16	16.550	16½	1.440	1 7/16	31⅛	2 9/16	1½
×245	72.1	36.08	36⅛	0.800	13/16	7/16	16.510	16½	1.350	1⅜	31⅛	2½	1 7/16
×230	67.6	35.90	35⅞	0.760	¾	⅜	16.470	16 ½	1.260	1¼	31⅛	2⅜	1 7/16
W 36×210	61.8	36.69	36¾	0.830	13/16	7/16	12.180	12⅛	1.360	1⅜	32⅛	2 5/16	1¼
×194	57.0	36.49	36½	0.765	¾	⅜	12.115	12⅛	1.260	1¼	32⅛	2 3/16	1 3/16
×182	53.6	36.33	36⅜	0.725	¾	⅜	12.075	12⅛	1.180	1 3/16	32⅛	2⅛	1 3/16
×170	50.0	36.17	36⅛	0.680	11/16	⅜	12.030	12	1.100	1⅛	32⅛	2	1 3/16
×160	47.0	36.01	36	0.650	⅝	5/16	12.000	12	1.020	1	32⅛	1 15/16	1⅛
×150	44.2	35.85	35⅞	0.625	⅝	5/16	11.975	12	0.940	5/16	32⅛	1⅞	1⅛
×135	39.7	35.55	35½	0.600	⅝	5/16	11.950	12	0.790	13/16	32⅛	1 11/16	1⅛
W 33×241	70.9	34.18	34⅛	0.830	13/16	7/16	15.860	15⅞	1.400	1⅜	29¾	2 3/16	1 3/16
×221	65.0	33.93	33⅞	0.775	¾	⅜	15.805	15¾	1.275	1¼	29¾	2 1/16	1 3/16
×201	59.1	33.68	33⅝	0.715	11/16	⅜	15.745	15¾	1.150	1⅛	29¾	1 15/16	1⅛
W 33×152	44.7	33.49	33½	0.635	⅝	5/16	11.565	11⅝	1.055	1 1/16	29¾	1⅞	1⅛
×141	41.6	33.30	33¼	0.605	⅝	5/16	11.535	11½	0.960	15/16	29¾	1¾	1 1/16
×130	38.3	33.09	33⅛	0.580	9/16	5/16	11.510	11½	0.855	⅞	29¾	1 11/16	1 1/16
×118	34.7	32.86	32⅞	0.550	9/16	5/16	11.480	11½	0.740	¾	29¾	1 9/16	1 1/16
W 30×211	62.0	30.94	31	0.775	¾	⅜	15.105	15⅛	1.315	1 5/16	26¾	2⅛	1⅛
×191	56.1	30.68	30⅝	0.710	11/16	⅜	15.040	15	1.185	1 3/16	26¾	1 15/16	1 1/16
×173	50.8	30.44	30½	0.655	⅝	5/16	14.985	15	1.065	1 1/16	26¾	1⅞	1 1/16
W 30×132	38.9	30.31	30¼	0.615	⅝	5/16	10.545	10½	1.000	1	26¾	1¾	1 1/16
×124	36.5	30.17	30⅛	0.585	9/16	5/16	10.515	10½	0.930	15/16	26¾	1 11/16	1
×116	34.2	30.01	30	0.565	9/16	5/16	10.495	10½	0.850	⅞	26¾	1⅝	1
×108	31.7	29.83	29⅞	0.545	9/16	5/16	10.475	10½	0.760	¾	26¾	1 9/16	1
× 99	29.1	29.65	29⅝	0.520	½	¼	10.450	10½	0.670	11/16	26¾	1 7/16	1

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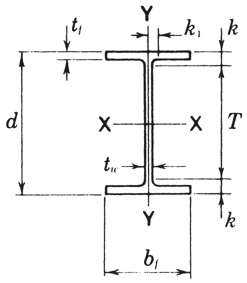

W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
W 27×178	52.3	27.81	27¾	0.725	¾	⅜	14.085	14⅛	1.190	1 3/16	24	1⅞	1 1/16
×161	47.4	27.59	27⅝	0.660	11/16	⅜	14.020	14	1.080	1 1/16	24	1 13/16	1
×146	42.9	27.38	27⅜	0.605	⅝	5/16	13.965	14	0.975	1	24	1 11/16	1
W 27×114	33.5	27.29	27¼	0.570	9/16	5/16	10.070	10⅛	0.930	15/16	24	1⅝	15/16
×102	30.0	27.09	27⅛	0.515	½	¼	10.015	10	0.830	13/16	24	1 9/16	15/16
× 94	27.7	26.92	26⅞	0.490	½	¼	9.990	10	0.745	¾	24	1 7/16	15/16
× 84	24.8	26.71	26¾	0.460	7/16	¼	9.960	10	0.640	⅝	24	1⅜	15/16
W 24×162	47.7	25.00	25	0.705	11/16	⅜	12.955	13	1.220	1¼	21	2	1 1/16
×146	43.0	24.74	24¾	0.650	⅝	5/16	12.900	12⅞	1.090	1 1/16	21	1⅞	1 1/16
×131	38.5	24.48	24½	0.605	⅝	5/16	12.855	12⅞	0.960	15/16	21	1¾	1 1/16
×117	34.4	24.26	24¼	0.550	9/16	5/16	12.800	12¾	0.850	⅞	21	1⅝	1
×104	30.6	24.06	24	0.500	½	¼	12.750	12¾	0.750	¾	21	1½	1
W 24× 94	27.7	24.31	24¼	0.515	½	¼	9.065	9⅛	0.875	⅞	21	1⅝	1
× 84	24.7	24.10	24⅛	0.470	½	¼	9.020	9	0.770	¾	21	1 9/16	15/16
× 76	22.4	23.92	23⅞	0.440	7/16	¼	8.990	9	0.680	11/16	21	1 7/16	15/16
× 68	20.1	23.73	23¾	0.415	7/16	¼	8.965	9	0.585	9/16	21	1⅜	15/16
W 24× 62	18.2	23.74	23¾	0.430	7/16	¼	7.040	7	0.590	9/16	21	1⅜	15/16
× 55	16.2	23.57	23⅝	0.395	⅜	3/16	7.005	7	0.505	½	21	1 5/16	15/16
W 21×147	43.2	22.06	22	0.720	¾	⅜	12.510	12½	1.150	1⅛	18¼	1⅞	1 1/16
×132	38.8	21.83	21⅞	0.650	⅝	5/16	12.440	12½	1.035	1 1/16	18¼	1 13/16	1
×122	35.9	21.68	21⅝	0.600	⅝	5/16	12.390	12⅜	0.960	15/16	18¼	1 11/16	1
×111	32.7	21.51	21½	0.550	9/16	5/16	12.340	12⅜	0.875	⅞	18¼	1⅝	15/16
×101	29.8	21.36	21⅜	0.500	½	¼	12.290	12¼	0.800	13/16	18¼	1 9/16	15/16
W 21× 93	27.3	21.62	21⅝	0.580	9/16	5/16	8.420	8⅜	0.930	15/16	18¼	1 11/16	1
× 83	24.3	21.43	21⅜	0.515	½	¼	8.355	8⅜	0.835	13/16	18¼	1 9/16	15/16
× 73	21.5	21.24	21¼	0.455	7/16	¼	8.295	8¼	0.740	¾	18¼	1½	15/16
× 68	20.0	21.13	21⅛	0.430	7/16	¼	8.270	8¼	0.685	11/16	18¼	1 7/16	⅞
× 62	18.3	20.99	21	0.400	⅜	3/16	8.240	8¼	0.615	⅝	18¼	1⅜	⅞
W 21× 57	16.7	21.06	21	0.405	⅜	3/16	6.555	6½	0.650	⅝	18¼	1⅜	⅞
× 50	14.7	20.83	20⅞	0.380	⅜	3/16	6.530	6½	0.535	9/16	18¼	1 5/16	⅞
× 44	13.0	20.66	20⅝	0.350	⅜	3/16	6.500	6½	0.450	7/16	18¼	1 3/16	⅞

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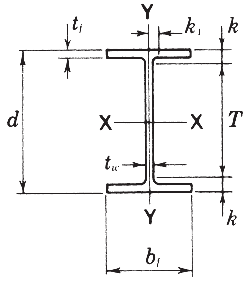

W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
W 18×119	35.1	18.97	19	0.655	⅝	5/16	11.265	11¼	1.060	1 1/16	15½	1¾	15/16
×106	31.1	18.73	18¾	0.590	9/16	5/16	11.200	11¼	0.940	15/16	15½	1⅝	15/16
× 97	28.5	18.59	18⅝	0.535	9/16	5/16	11.145	11⅛	0.870	⅞	15½	1 9/16	⅞
× 86	25.3	18.39	18⅜	0.480	½	¼	11.090	11⅛	0.770	¾	15½	1 7/16	⅞
× 76	22.3	18.21	18¼	0.425	7/16	¼	11.035	11	0.680	11/16	15½	1⅜	13/16
W 18× 71	20.8	18.47	18½	0.495	½	¼	7.635	7⅝	0.810	13/16	15½	1½	⅞
× 65	19.1	18.35	18⅜	0.450	7/16	¼	7.590	7⅝	0.750	¾	15½	1 7/16	⅞
× 60	17.6	18.24	18¼	0.415	7/16	¼	7.555	7½	0.695	11/16	15½	1⅜	13/16
× 55	16.2	18.11	18⅛	0.390	⅜	3/16	7.530	7½	0.630	⅝	15½	1 5/16	13/16
× 50	14.7	17.99	18	0.355	⅜	3/16	7.495	7½	0.570	9/16	15½	1¼	13/16
W 18× 46	13.5	18.06	18	0.360	⅜	3/16	6.060	6	0.605	⅝	15½	1¼	13/16
× 40	11.8	17.90	17⅞	0.315	5/16	3/16	6.015	6	0.525	½	15½	1 3/16	13/16
× 35	10.3	17.70	17¾	0.300	5/16	3/16	6.000	6	0.425	7/16	15½	1⅛	¾
W 16×100	29.4	16.97	17	0.585	9/16	5/16	10.425	10⅜	0.985	1	13⅝	1 11/16	15/16
× 89	26.2	16.75	16¾	0.525	½	¼	10.365	10⅜	0.875	⅞	13⅝	1 9/16	⅞
× 77	22.6	16.52	16½	0.455	7/16	¼	10.295	10¼	0.760	¾	13⅝	1 7/16	⅞
× 67	19.7	16.33	16⅜	0.395	⅜	3/16	10.235	10¼	0.665	11/16	13⅝	1⅜	13/16
W 16× 57	16.8	16.43	16⅜	0.430	7/16	¼	7.120	7⅛	0.715	11/16	13⅝	1⅜	⅞
× 50	14.7	16.26	16¼	0.380	⅜	3/16	7.070	7⅛	0.630	⅝	13⅝	1 5/16	13/16
× 45	13.3	16.13	16⅛	0.345	⅜	3/16	7.035	7	0.565	9/16	13⅝	1¼	13/16
× 40	11.8	16.01	16	0.305	5/16	3/16	6.995	7	0.505	½	13⅝	1 3/16	13/16
× 36	10.6	15.86	15⅞	0.295	5/16	3/16	6.985	7	0.430	7/16	13⅝	1⅛	¾
W 16× 31	9.12	15.88	15⅞	0.275	¼	⅛	5.525	5½	0.440	7/16	13⅝	1⅛	¾
× 26	7.68	15.69	15¾	0.250	¼	⅛	5.500	5½	0.345	⅜	13⅝	1 1/16	¾

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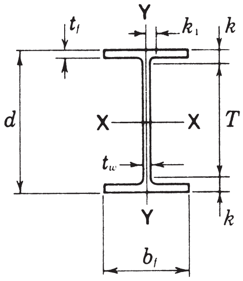

W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
W 14×730	215.0	22.42	22 3/8	3.070	3 1/16	1 9/16	17.890	17 7/8	4.910	4 15/16	11 1/4	5 9/16	2 3/16
×665	196.0	21.64	21 5/8	2.830	2 13/16	1 7/16	17.650	17 5/8	4.520	4 1/2	11 1/4	5 3/16	2 1/16
×605	178.0	20.92	20 7/8	2.595	2 5/8	1 5/16	17.415	17 3/8	4.160	4 3/16	11 1/4	4 13/16	1 15/16
×550	162.0	20.24	20 1/4	2.380	2 3/8	1 3/16	17.200	17 1/4	3.820	3 13/16	11 1/4	4 1/2	1 13/16
×500	147.0	19.60	19 5/8	2.190	2 3/16	1 1/8	17.010	17	3.500	3 1/2	11 1/4	4 3/16	1 3/4
×455	134.0	19.02	19	2.015	2	1	16.835	16 7/8	3.210	3 3/16	11 1/4	3 7/8	1 5/8
W 14×426	125.0	18.67	18 5/8	1.875	1 7/8	15/16	16.695	16 3/4	3.035	3 1/16	11 1/4	3 11/16	1 9/16
×398	117.0	18.29	18 1/4	1.770	1 3/4	7/8	16.590	16 5/8	2.845	2 7/8	11 1/4	3 1/2	1 1/2
×370	109.0	17.92	17 7/8	1.655	1 5/8	13/16	16.475	16 1/2	2.660	2 11/16	11 1/4	3 5/16	1 7/16
×342	101.0	17.54	17 1/2	1.540	1 9/16	13/16	16.360	16 3/8	2.470	2 1/2	11 1/4	3 1/8	1 3/8
×311	91.4	17.12	17 1/8	1.410	1 7/16	3/4	16.230	16 1/4	2.260	2 1/4	11 1/4	2 15/16	1 5/16
×283	83.3	16.74	16 3/4	1.290	1 5/16	11/16	16.110	16 1/8	2.070	2 1/16	11 1/4	2 3/4	1 1/4
×257	75.6	16.38	16 3/8	1.175	1 3/16	5/8	15.995	16	1.890	1 7/8	11 1/4	2 9/16	1 3/16
×233	68.5	16.04	16	1.070	1 1/16	9/16	15.890	15 7/8	1.720	1 3/4	11 1/4	2 3/8	1 3/16
×211	62.0	15.72	15 3/4	0.980	1	1/2	15.800	15 3/4	1.560	1 9/16	11 1/4	2 1/4	1 1/8
×193	56.8	15.48	15 1/2	0.890	7/8	7/16	15.710	15 3/4	1.440	1 7/16	11 1/4	2 1/8	1 1/16
×176	51.8	15.22	15 1/4	0.830	13/16	7/16	15.650	15 5/8	1.310	1 5/16	11 1/4	2	1 1/16
×159	46.7	14.98	15	0.745	3/4	3/8	15.565	15 5/8	1.190	1 3/16	11 1/4	1 7/8	1
×145	42.7	14.78	14 3/4	0.680	11/16	3/8	15.500	15 1/2	1.090	1 1/16	11 1/4	1 3/4	1

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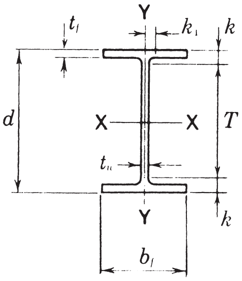

W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
W 14×132	38.8	14.66	14 5/8	0.645	5/8	5/16	14.725	14 3/4	1.030	1	11 1/4	1 11/16	15/16
×120	35.3	14.48	14 1/2	0.590	9/16	5/16	14.670	14 5/8	0.940	15/16	11 1/4	1 5/8	15/16
×109	32.0	14.32	14 3/8	0.525	1/2	1/4	14.605	14 5/8	0.860	7/8	11 1/4	1 9/16	7/8
× 99	29.1	14.16	14 1/8	0.485	1/2	1/4	14.565	14 5/8	0.780	3/4	11 1/4	1 7/16	7/8
× 90	26.5	14.02	14	0.440	7/16	1/4	14.520	14 1/2	0.710	11/16	11 1/4	1 3/8	7/8
W 14× 82	24.1	14.31	14 1/4	0.510	1/2	1/4	10.130	10 1/8	0.855	7/8	11	1 5/8	1
× 74	21.8	14.17	14 1/8	0.450	7/16	1/4	10.070	10 1/8	0.785	13/16	11	1 9/16	15/16
× 68	20.0	14.04	14	0.415	7/16	1/4	10.035	10	0.720	3/4	11	1 1/2	15/16
× 61	17.9	13.89	13 7/8	0.375	3/8	3/16	9.995	10	0.645	5/8	11	1 7/16	15/16
W 14× 53	15.6	13.92	13 7/8	0.370	3/8	3/16	8.060	8	0.660	11/16	11	1 7/16	15/16
× 48	14.1	13.79	13 3/4	0.340	5/16	3/16	8.030	8	0.595	5/8	11	1 3/8	7/8
× 43	12.6	13.66	13 5/8	0.305	5/16	3/16	7.995	8	0.530	1/2	11	1 5/16	7/8
W 14× 38	11.2	14.10	14 1/8	0.310	5/16	3/16	6.770	6 3/4	0.515	1/2	12	1 1/16	5/8
× 34	10.0	13.98	14	0.285	5/16	3/16	6.745	6 3/4	0.455	7/16	12	1	5/8
× 30	8.85	13.84	13 7/8	0.270	1/4	1/8	6.730	6 3/4	0.385	3/8	12	15/16	5/8
W 14× 26	7.69	13.91	13 7/8	0.255	1/4	1/8	5.025	5	0.420	7/16	12	15/16	9/16
× 22	6.49	13.74	13 3/4	0.230	1/4	1/8	5.000	5	0.335	5/16	12	7/8	9/16

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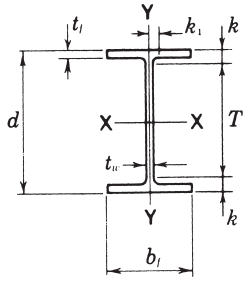

W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
W 12×336	98.8	16.82	16⅞	1.775	1¾	⅞	13.385	13⅜	2.955	2¹⁵⁄₁₆	9½	3¹¹⁄₁₆	1½
×305	89.6	16.32	16⅜	1.625	1⅝	¹³⁄₁₆	13.235	13¼	2.705	2¹¹⁄₁₆	9½	3⁷⁄₁₆	1⁷⁄₁₆
×279	81.9	15.85	15⅞	1.530	1½	¾	13.140	13⅛	2.470	2½	9½	3³⁄₁₆	1⅜
×252	74.1	15.41	15⅜	1.395	1⅜	¹¹⁄₁₆	13.005	13	2.250	2¼	9½	2¹⁵⁄₁₆	1⁵⁄₁₆
×230	67.7	15.05	15	1.285	1⁵⁄₁₆	¹¹⁄₁₆	12.895	12⅞	2.070	2¹⁄₁₆	9½	2¾	1¼
×210	61.8	14.71	14¾	1.180	1³⁄₁₆	⅝	12.790	12¾	1.900	1⅞	9½	2⅝	1¼
×190	55.8	14.38	14⅜	1.060	1¹⁄₁₆	⁹⁄₁₆	12.670	12⅝	1.735	1¾	9½	2⁷⁄₁₆	1³⁄₁₆
×170	50.0	14.03	14	0.960	¹⁵⁄₁₆	½	12.570	12⅝	1.560	1⁹⁄₁₆	9½	2¼	1⅛
×152	44.7	13.71	13¾	0.870	⅞	⁷⁄₁₆	12.480	12½	1.400	1⅜	9½	2⅛	1¹⁄₁₆
×136	39.9	13.41	13⅜	0.790	¹³⁄₁₆	⁷⁄₁₆	12.400	12⅜	1.250	1¼	9½	1¹⁵⁄₁₆	1
×120	35.3	13.12	13⅛	0.710	¹¹⁄₁₆	⅜	12.320	12⅜	1.105	1⅛	9½	1¹³⁄₁₆	1
×106	31.2	12.89	12⅞	0.610	⅝	⁵⁄₁₆	12.220	12¼	0.990	1	9½	1¹¹⁄₁₆	¹⁵⁄₁₆
× 96	28.2	12.71	12¾	0.550	⁹⁄₁₆	⁵⁄₁₆	12.160	12⅛	0.900	⅞	9½	1⅝	⅞
× 87	25.6	12.53	12½	0.515	½	¼	12.125	12⅛	0.810	¹³⁄₁₆	9½	1½	⅞
× 79	23.2	12.38	12⅜	0.470	½	¼	12.080	12⅛	0.735	¾	9½	1⁷⁄₁₆	⅞
× 72	21.1	12.25	12¼	0.430	⁷⁄₁₆	¼	12.040	12	0.670	¹¹⁄₁₆	9½	1⅜	⅞
× 65	19.1	12.12	12⅛	0.390	⅜	³⁄₁₆	12.000	12	0.605	⅝	9½	1⁵⁄₁₆	¹³⁄₁₆
W 12× 58	17.0	12.19	12¼	0.360	⅜	³⁄₁₆	10.010	10	0.640	⅝	9½	1⅜	¹³⁄₁₆
× 53	15.6	12.06	12	0.345	⅜	³⁄₁₆	9.995	10	0.575	⁹⁄₁₆	9½	1¼	¹³⁄₁₆
W 12× 50	14.7	12.19	12¼	0.370	⅜	³⁄₁₆	8.080	8⅛	0.640	⅝	9½	1⅜	¹³⁄₁₆
× 45	13.2	12.06	12	0.335	⁵⁄₁₆	³⁄₁₆	8.045	8	0.575	⁹⁄₁₆	9½	1¼	¹³⁄₁₆
× 40	11.8	11.94	12	0.295	⁵⁄₁₆	³⁄₁₆	8.005	8	0.515	½	9½	1¼	¾
W 12× 35	10.3	12.50	12½	0.300	⁵⁄₁₆	³⁄₁₆	6.560	6½	0.520	½	10½	1	⁹⁄₁₆
× 30	8.79	12.34	12⅜	0.260	¼	⅛	6.520	6½	0.440	⁷⁄₁₆	10½	¹⁵⁄₁₆	½
× 26	7.65	12.22	12¼	0.230	¼	⅛	6.490	6½	0.380	⅜	10½	⅞	½
W 12× 22	6.48	12.31	12¼	0.260	¼	⅛	4.030	4	0.425	⁷⁄₁₆	10½	⅞	½
× 19	5.57	12.16	12⅛	0.235	¼	⅛	4.005	4	0.350	⅜	10½	¹³⁄₁₆	½
× 16	4.71	11.99	12	0.220	¼	⅛	3.990	4	0.265	¼	10½	¾	½
× 14	4.16	11.91	11⅞	0.200	³⁄₁₆	⅛	3.970	4	0.225	¼	10½	¹¹⁄₁₆	½

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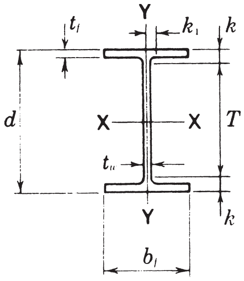

W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
W 10×112	32.9	11.36	11⅜	0.755	¾	⅜	10.415	10⅜	1.250	1¼	7⅝	1⅞	15/16
×100	29.4	11.10	11⅛	0.680	11/16	⅜	10.340	10⅜	1.120	1⅛	7⅝	1¾	⅞
× 88	25.9	10.84	10⅞	0.605	⅝	5/16	10.265	10¼	0.990	1	7⅝	1⅝	13/16
× 77	22.6	10.60	10⅝	0.530	½	¼	10.190	10¼	0.870	⅞	7⅝	1½	13/16
× 68	20.0	10.40	10⅜	0.470	½	¼	10.130	10⅛	0.770	¾	7⅝	1⅜	¾
× 60	17.6	10.22	10¼	0.420	7/16	¼	10.080	10⅛	0.680	11/16	7⅝	1 5/16	¾
× 54	15.8	10.09	10⅛	0.370	⅜	3/16	10.030	10	0.615	⅝	7⅝	1¼	11/16
× 49	14.4	9.98	10	0.340	5/16	3/16	10.000	10	0.560	9/16	7⅝	1 3/16	11/16
W 10× 45	13.3	10.10	10⅛	0.350	⅜	3/16	8.020	8	0.620	⅝	7⅝	1¼	11/16
× 39	11.5	9.92	9⅞	0.315	5/16	3/16	7.985	8	0.530	½	7⅝	1⅛	11/16
× 33	9.71	9.73	9¾	0.290	5/16	3/16	7.960	8	0.435	7/16	7⅝	1 1/16	11/16
W 10× 30	8.84	10.47	10½	0.300	5/16	3/16	5.810	5¾	0.510	½	8⅝	15/16	½
× 26	7.61	10.33	10⅜	0.260	¼	⅛	5.770	5¾	0.440	7/16	8⅝	⅞	½
× 22	6.49	10.17	10⅛	0.240	¼	⅛	5.750	5¾	0.360	⅜	8⅝	¾	½
W 10× 19	5.62	10.24	10¼	0.250	¼	⅛	4.020	4	0.395	⅜	8⅝	13/16	½
× 17	4.99	10.11	10⅛	0.240	¼	⅛	4.010	4	0.330	5/16	8⅝	¾	½
× 15	4.41	9.99	10	0.230	¼	⅛	4.000	4	0.270	¼	8⅝	11/16	7/16
× 12	3.54	9.87	9⅞	0.190	3/16	⅛	3.960	4	0.210	3/16	8⅝	⅝	7/16

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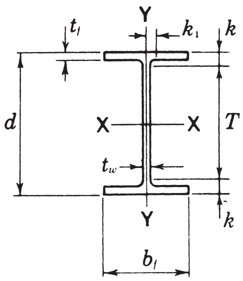

W SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.²	In.		In.		In.	In.		In.		In.	In.	In.
W 8×67	19.7	9.00	9	0.570	9/16	5/16	8.280	8¼	0.935	15/16	6⅛	1 7/16	11/16
×58	17.1	8.75	8¾	0.510	½	¼	8.220	8¼	0.810	13/16	6⅛	1 5/16	11/16
×48	14.1	8.50	8½	0.400	⅜	3/16	8.110	8⅛	0.685	11/16	6⅛	1 3/16	⅝
×40	11.7	8.25	8¼	0.360	⅜	3/16	8.070	8⅛	0.560	9/16	6⅛	1 1/16	⅝
×35	10.3	8.12	8⅛	0.310	5/16	3/16	8.020	8	0.495	½	6⅛	1	9/16
×31	9.13	8.00	8	0.285	5/16	3/16	7.995	8	0.435	7/16	6⅛	15/16	9/16
W 8×28	8.25	8.06	8	0.285	5/16	3/16	6.535	6½	0.465	7/16	6⅛	15/16	9/16
×24	7.08	7.93	7⅞	0.245	¼	⅛	6.495	6½	0.400	⅜	6⅛	⅞	9/16
W 8×21	6.16	8.28	8¼	0.250	¼	⅛	5.270	5¼	0.400	⅜	6⅝	13/16	½
×18	5.26	8.14	8⅛	0.230	¼	⅛	5.250	5¼	0.330	5/16	6⅝	¾	7/16
W 8×15	4.44	8.11	8⅛	0.245	¼	⅛	4.015	4	0.315	5/16	6⅝	¾	½
×13	3.84	7.99	8	0.230	¼	⅛	4.000	4	0.255	¼	6⅝	11/16	7/16
×10	2.96	7.89	7⅞	0.170	3/16	⅛	3.940	4	0.205	3/16	6⅝	⅝	7/16
W 6×25	7.34	6.38	6⅜	0.320	5/16	3/16	6.080	6⅛	0.455	7/16	4¾	13/16	7/16
×20	5.87	6.20	6¼	0.260	¼	⅛	6.020	6	0.365	⅜	4¾	¾	7/16
×15	4.43	5.99	6	0.230	¼	⅛	5.990	6	0.260	¼	4¾	⅝	⅜
W 6×16	4.74	6.28	6¼	0.260	¼	⅛	4.030	4	0.405	⅜	4¾	¾	7/16
×12	3.55	6.03	6	0.230	¼	⅛	4.000	4	0.280	¼	4¾	⅝	⅜
× 9	2.68	5.90	5⅞	0.170	3/16	⅛	3.940	4	0.215	3/16	4¾	9/16	⅜
W 5×19	5.54	5.15	5⅛	0.270	¼	⅛	5.030	5	0.430	7/16	3½	13/16	7/16
×16	4.68	5.01	5	0.240	¼	⅛	5.000	5	0.360	⅜	3½	¾	7/16
W 4×13	3.83	4.16	4⅛	0.280	¼	⅛	4.060	4	0.345	⅜	2¾	11/16	7/16

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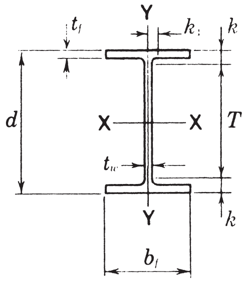

M SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		Grip	Max. Flge. Fastener
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k		
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.	In.
M 14×18	5.10	14.00	14	0.215	3⁄16	⅛	4.000	4	0.270	¼	12¾	⅝	¼	¾
M 12×11.8	3.47	12.00	12	0.177	3⁄16	⅛	3.065	3⅛	0.225	¼	10⅞	9⁄16	¼	—
M 10×9	2.65	10.00	10	0.157	3⁄16	⅛	2.690	2¾	0.206	3⁄16	8⅞	9⁄16	3⁄16	—
M 8×6.5	1.92	8.00	8	0.135	⅛	1⁄16	2.281	2¼	0.189	3⁄16	7	½	3⁄16	—
M 6×20	5.89	6.00	6	0.250	¼	⅛	5.938	6	0.379	⅜	4¼	⅞	⅜	⅞
M 6×4.4	1.29	6.00	6	0.114	⅛	1⁄16	1.844	1⅞	0.171	3⁄16	5⅛	7⁄16	3⁄16	—
M 5×18.9	5.55	5.00	5	0.316	5⁄16	3⁄16	5.003	5	0.416	7⁄16	3¼	⅞	7⁄16	⅞
M 4×13	3.81	4.00	4	0.254	¼	⅛	3.940	4	0.371	⅜	2⅜	13⁄16	⅜	¾

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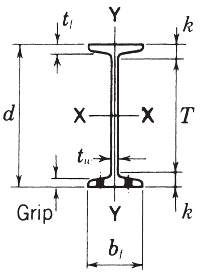

S SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		Grip	Max. Flge. Fastener
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k		
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.	In.
S 24×121	35.6	24.50	24½	0.800	¹³⁄₁₆	⁷⁄₁₆	8.050	8	1.090	1¹⁄₁₆	20½	2	1⅛	1
×106	31.2	24.50	24½	0.620	⅝	⁵⁄₁₆	7.870	7⅞	1.090	1¹⁄₁₆	20½	2	1⅛	1
S 24×100	29.3	24.00	24	0.745	¾	⅜	7.245	7¼	0.870	⅞	20½	1¾	⅞	1
×90	26.5	24.00	24	0.625	⅝	⁵⁄₁₆	7.125	7⅛	0.870	⅞	20½	1¾	⅞	1
×80	23.5	24.00	24	0.500	½	¼	7.000	7	0.870	⅞	20½	1¾	⅞	1
S 20×96	28.2	20.30	20¼	0.800	¹³⁄₁₆	⁷⁄₁₆	7.200	7¼	0.920	¹⁵⁄₁₆	16¾	1¾	¹⁵⁄₁₆	1
×86	25.3	20.30	20¼	0.660	¹¹⁄₁₆	⅜	7.060	7	0.920	¹⁵⁄₁₆	16¾	1¾	¹⁵⁄₁₆	1
S 20×75	22.0	20.00	20	0.635	⅝	⁵⁄₁₆	6.385	6⅜	0.795	¹³⁄₁₆	16¾	1⅝	¹³⁄₁₆	⅞
×66	19.4	20.00	20	0.505	½	¼	6.255	6¼	0.795	¹³⁄₁₆	16¾	1⅝	¹³⁄₁₆	⅞
S 18×70	20.6	18.00	18	0.711	¹¹⁄₁₆	⅜	6.251	6¼	0.691	¹¹⁄₁₆	15	1½	¹¹⁄₁₆	⅞
×54.7	16.1	18.00	18	0.461	⁷⁄₁₆	¼	6.001	6	0.691	¹¹⁄₁₆	15	1½	¹¹⁄₁₆	⅞
S 15×50	14.7	15.00	15	0.550	⁹⁄₁₆	⁵⁄₁₆	5.640	5⅝	0.622	⅝	12¼	1⅜	⁹⁄₁₆	¾
×42.9	12.6	15.00	15	0.411	⁷⁄₁₆	¼	5.501	5½	0.622	⅝	12¼	1⅜	⁹⁄₁₆	¾
S 12×50	14.7	12.00	12	0.687	¹¹⁄₁₆	⅜	5.477	5½	0.659	¹¹⁄₁₆	9⅛	1⁷⁄₁₆	¹¹⁄₁₆	¾
×40.8	12.0	12.00	12	0.462	⁷⁄₁₆	¼	5.252	5¼	0.659	¹¹⁄₁₆	9⅛	1⁷⁄₁₆	⅝	¾
S 12×35	10.3	12.00	12	0.428	⁷⁄₁₆	¼	5.078	5⅛	0.544	⁹⁄₁₆	9⅝	1³⁄₁₆	½	¾
×31.8	9.35	12.00	12	0.350	⅜	³⁄₁₆	5.000	5	0.544	⁹⁄₁₆	9⅝	1³⁄₁₆	½	¾
S 10×35	10.3	10.00	10	0.594	⅝	⁵⁄₁₆	4.944	5	0.491	½	7¾	1⅛	½	¾
×25.4	7.46	10.00	10	0.311	⁵⁄₁₆	³⁄₁₆	4.661	4⅝	0.491	½	7¾	1⅛	½	¾
S 8×23	6.77	8.00	8	0.441	⁷⁄₁₆	¼	4.171	4⅛	0.426	⁷⁄₁₆	6	1	⁷⁄₁₆	¾
×18.4	5.41	8.00	8	0.271	¼	⅛	4.001	4	0.426	⁷⁄₁₆	6	1	⁷⁄₁₆	¾
S 7×20	5.88	7.00	7	0.450	⁷⁄₁₆	¼	3.860	3⅞	0.392	⅜	5⅛	¹⁵⁄₁₆	⅜	⅝
×15.3	4.50	7.00	7	0.252	¼	⅛	3.662	3⅝	0.392	⅜	5⅛	¹⁵⁄₁₆	⅜	⅝
S 6×17.25	5.07	6.00	6	0.465	⁷⁄₁₆	¼	3.565	3⅝	0.359	⅜	4¼	⅞	⅜	⅝
×12.5	3.67	6.00	6	0.232	¼	⅛	3.332	3⅜	0.359	⅜	4¼	⅞	⅜	—
S 5×14.75	4.34	5.00	5	0.494	½	¼	3.284	3¼	0.326	⁵⁄₁₆	3⅜	¹³⁄₁₆	⁵⁄₁₆	—
×10	2.94	5.00	5	0.214	³⁄₁₆	⅛	3.004	3	0.326	⁵⁄₁₆	3⅜	¹³⁄₁₆	⁵⁄₁₆	—
S 4×9.5	2.79	4.00	4	0.326	⁵⁄₁₆	³⁄₁₆	2.796	2¾	0.293	⁵⁄₁₆	2½	¾	⁵⁄₁₆	—
×7.7	2.26	4.00	4	0.193	³⁄₁₆	⅛	2.663	2⅝	0.293	⁵⁄₁₆	2½	¾	⁵⁄₁₆	—
S 3×7.5	2.21	3.00	3	0.349	⅜	³⁄₁₆	2.509	2½	0.260	¼	1⅝	¹¹⁄₁₆	¼	—
×5.7	1.67	3.00	3	0.170	³⁄₁₆	⅛	2.330	2⅜	0.260	¼	1⅝	¹¹⁄₁₆	¼	—

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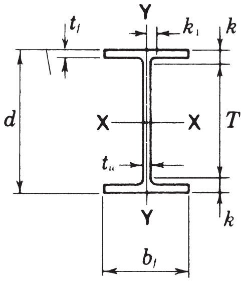

HP SHAPES
Dimensions

Designation	Area A	Depth d		Web			Flange				Distance		
				Thickness t_w		$\frac{t_w}{2}$	Width b_f		Thickness t_f		T	k	k_1
	In.^{2}	In.		In.		In.	In.		In.		In.	In.	In.
HP 14×117	34.4	14.21	14¼	0.805	13⁄16	7⁄16	14.885	14⅞	0.805	13⁄16	11¼	1½	1 1⁄16
×102	30.0	14.01	14	0.705	11⁄16	⅜	14.785	14¾	0.705	11⁄16	11¼	1⅜	1
× 89	26.1	13.83	13⅞	0.615	⅝	5⁄16	14.695	14¾	0.615	⅝	11¼	1 5⁄16	15⁄16
× 73	21.4	13.61	13⅝	0.505	½	¼	14.585	14⅝	0.505	½	11¼	1 3⁄16	⅞
HP 13×100	29.4	13.15	13⅛	0.765	¾	⅜	13.205	13¼	0.765	¾	10¼	1 7⁄16	1
× 87	25.5	12.95	13	0.665	11⁄16	⅜	13.105	13⅛	0.665	11⁄16	10¼	1⅜	15⁄16
× 73	21.6	12.75	12¾	0.565	9⁄16	5⁄16	13.005	13	0.565	9⁄16	10¼	1¼	15⁄16
× 60	17.5	12.54	12½	0.460	7⁄16	¼	12.900	12⅞	0.460	7⁄16	10¼	1⅛	⅞
HP 12× 84	24.6	12.28	12¼	0.685	11⁄16	⅜	12.295	12¼	0.685	11⁄16	9½	1⅜	1
× 74	21.8	12.13	12⅛	0.605	⅝	5⁄16	12.215	12¼	0.610	⅝	9½	1 5⁄16	15⁄16
× 63	18.4	11.94	12	0.515	½	¼	12.125	12⅛	0.515	½	9½	1¼	⅞
× 53	15.5	11.78	11¾	0.435	7⁄16	¼	12.045	12	0.435	7⁄16	9½	1⅛	⅞
HP 10× 57	16.8	9.99	10	0.565	9⁄16	5⁄16	10.225	10¼	0.565	9⁄16	7⅝	1 3⁄16	13⁄16
× 42	12.4	9.70	9¾	0.415	7⁄16	¼	10.075	10⅛	0.420	7⁄16	7⅝	1 1⁄16	¾
HP 8× 36	10.6	8.02	8	0.445	7⁄16	¼	8.155	8⅛	0.445	7⁄16	6⅛	15⁄16	⅝

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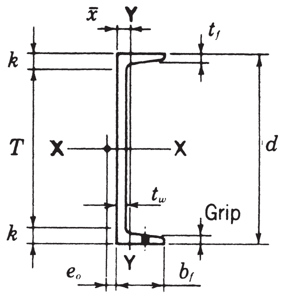

CHANNELS
AMERICAN STANDARD
Dimensions

Designation	Area A	Depth d	Web			Flange				Distance		Grip	Max. Flge. Fastener
			Thickness t_w		$\frac{t_w}{2}$	Width b_f		Average Thickness t_f		T	k		
	In.^{2}	In.	In.		In.	In.		In.		In.	In.	In.	In.
C 15×50	14.7	15.00	0.716	11/16	3/8	3.716	3 3/4	0.650	5/8	12 1/8	1 7/16	5/8	1
×40	11.8	15.00	0.520	1/2	1/4	3.520	3 1/2	0.650	5/8	12 1/8	1 7/16	5/8	1
×33.9	9.96	15.00	0.400	3/8	3/16	3.400	3 3/8	0.650	5/8	12 1/8	1 7/16	5/8	1
C 12×30	8.82	12.00	0.510	1/2	1/4	3.170	3 1/8	0.501	1/2	9 3/4	1 1/8	1/2	7/8
×25	7.35	12.00	0.387	3/8	3/16	3.047	3	0.501	1/2	9 3/4	1 1/8	1/2	7/8
×20.7	6.09	12.00	0.282	5/16	1/8	2.942	3	0.501	1/2	9 3/4	1 1/8	1/2	7/8
C 10×30	8.82	10.00	0.673	11/16	5/16	3.033	3	0.436	7/16	8	1	7/16	3/4
×25	7.35	10.00	0.526	1/2	1/4	2.886	2 7/8	0.436	7/16	8	1	7/16	3/4
×20	5.88	10.00	0.379	3/8	3/16	2.739	2 3/4	0.436	7/16	8	1	7/16	3/4
×15.3	4.49	10.00	0.240	1/4	1/8	2.600	2 5/8	0.436	7/16	8	1	7/16	3/4
C 9×20	5.88	9.00	0.448	7/16	1/4	2.648	2 5/8	0.413	7/16	7 1/8	15/16	7/16	3/4
×15	4.41	9.00	0.285	5/16	1/8	2.485	2 1/2	0.413	7/16	7 1/8	15/16	7/16	3/4
×13.4	3.94	9.00	0.233	1/4	1/8	2.433	2 3/8	0.413	7/16	7 1/8	15/16	7/16	3/4
C 8×18.75	5.51	8.00	0.487	1/2	1/4	2.527	2 1/2	0.390	3/8	6 1/8	15/16	3/8	3/4
×13.75	4.04	8.00	0.303	5/16	1/8	2.343	2 3/8	0.390	3/8	6 1/8	15/16	3/8	3/4
×11.5	3.38	8.00	0.220	1/4	1/8	2.260	2 1/4	0.390	3/8	6 1/8	15/16	3/8	3/4
C 7×14.75	4.33	7.00	0.419	7/16	3/16	2.299	2 1/4	0.366	3/8	5 1/4	7/8	3/8	5/8
×12.25	3.60	7.00	0.314	5/16	3/16	2.194	2 1/4	0.366	3/8	5 1/4	7/8	3/8	5/8
× 9.8	2.87	7.00	0.210	3/16	1/8	2.090	2 1/8	0.366	3/8	5 1/4	7/8	3/8	5/8
C 6×13	3.83	6.00	0.437	7/16	3/16	2.157	2 1/8	0.343	5/16	4 3/8	13/16	5/16	5/8
×10.5	3.09	6.00	0.314	5/16	3/16	2.034	2	0.343	5/16	4 3/8	13/16	3/8	5/8
× 8.2	2.40	6.00	0.200	3/16	1/8	1.920	1 7/8	0.343	5/16	4 3/8	13/16	5/16	5/8
C 5× 9	2.64	5.00	0.325	5/16	3/16	1.885	1 7/8	0.320	5/16	3 1/2	3/4	5/16	5/8
× 6.7	1.97	5.00	0.190	3/16	1/8	1.750	1 3/4	0.320	5/16	3 1/2	3/4	—	—
C 4× 7.25	2.13	4.00	0.321	5/16	3/16	1.721	1 3/4	0.296	5/16	2 5/8	11/16	5/16	5/8
× 5.4	1.59	4.00	0.184	3/16	1/16	1.584	1 5/8	0.296	5/16	2 5/8	11/16	—	—
C 3× 6	1.76	3.00	0.356	3/8	3/16	1.596	1 5/8	0.273	1/4	1 5/8	11/16	—	—
× 5	1.47	3.00	0.258	1/4	1/8	1.498	1 1/2	0.273	1/4	1 5/8	11/16	—	—
× 4.1	1.21	3.00	0.170	3/16	1/16	1.410	1 3/8	0.273	1/4	1 5/8	11/16	—	—

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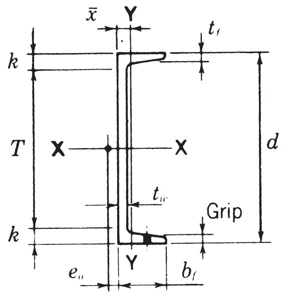

CHANNELS MISCELLANEOUS
Dimensions

Designation	Area A	Depth d	Web			Flange				Distance		Grip	Max. Flge. Fastener
			Thickness t_w		$\frac{t_w}{2}$	Width b_f		Average Thickness t_f		T	k		
	In.^{2}	In.	In.		In.	In.		In.		In.	In.	In.	In.
MC 18×58	17.1	18.00	0.700	11/16	⅜	4.200	4¼	0.625	⅝	15¼	1⅜	⅝	1
×51.9	15.3	18.00	0.600	⅝	5/16	4.100	4⅛	0.625	⅝	15¼	1⅜	⅝	1
×45.8	13.5	18.00	0.500	½	¼	4.000	4	0.625	⅝	15¼	1⅜	⅝	1
×42.7	12.6	18.00	0.450	7/16	¼	3.950	4	0.625	⅝	15¼	1⅜	⅝	1
MC 13×50	14.7	13.00	0.787	13/16	⅜	4.412	4⅜	0.610	⅝	10¼	1⅜	⅝	1
×40	11.8	13.00	0.560	9/16	¼	4.185	4⅛	0.610	⅝	10¼	1⅜	9/16	1
×35	10.3	13.00	0.447	7/16	¼	4.072	4⅛	0.610	⅝	10¼	1⅜	9/16	1
×31.8	9.35	13.00	0.375	⅜	3/16	4.000	4	0.610	⅝	10¼	1⅜	9/16	1
MC 12×50	14.7	12.00	0.835	13/16	7/16	4.135	4⅛	0.700	11/16	9⅜	1 5/16	11/16	1
×45	13.2	12.00	0.712	11/16	⅜	4.012	4	0.700	11/16	9⅜	1 5/16	11/16	1
×40	11.8	12.00	0.590	9/16	5/16	3.890	3⅞	0.700	11/16	9⅜	1 5/16	11/16	1
×35	10.3	12.00	0.467	7/16	¼	3.767	3¾	0.700	11/16	9⅜	1 5/16	11/16	1
MC 12×37	10.9	12.00	0.600	⅝	5/16	3.600	3⅝	0.600	⅝	9⅜	1 5/16	⅝	⅞
×32.9	9.67	12.00	0.500	½	¼	3.500	3½	0.600	⅝	9⅜	1 5/16	9/16	⅞
×30.9	9.07	12.00	0.450	7/16	¼	3.450	3½	0.600	⅝	9⅜	1 5/16	9/16	⅞
MC 12×10.6	3.10	12.00	0.190	3/16	⅛	1.500	1½	0.309	5/16	10⅝	11/16	—	—
MC 10×41.1	12.1	10.00	0.796	13/16	⅜	4.321	4⅜	0.575	9/16	7½	1¼	9/16	⅞
×33.6	9.87	10.00	0.575	9/16	5/16	4.100	4⅛	0.575	9/16	7½	1¼	9/16	⅞
×28.5	8.37	10.00	0.425	7/16	3/16	3.950	4	0.575	9/16	7½	1¼	9/16	⅞
MC 10×28.3	8.32	10.00	0.477	½	¼	3.502	3½	0.575	9/16	7½	1¼	9/16	⅞
×25.3	7.43	10.00	0.425	7/16	3/16	3.550	3½	0.500	½	7¾	1⅛	½	⅞
×24.9	7.32	10.00	0.377	⅜	3/16	3.402	3⅜	0.575	9/16	7½	1¼	9/16	⅞
×21.9	6.43	10.00	0.325	5/16	3/16	3.450	3½	0.500	½	7¾	1⅛	½	⅞
MC 10× 8.4	2.46	10.00	0.170	3/16	1/16	1.500	1½	0.280	¼	8⅝	11/16	—	—
MC 10× 6.5	1.91	10.00	0.152	⅛	1/16	1.127	1⅛	0.202	3/16	9⅛	7/16	—	—

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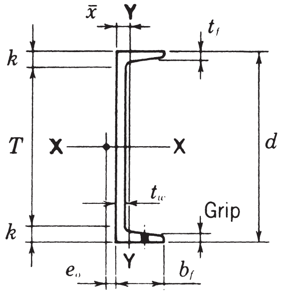

CHANNELS MISCELLANEOUS
Dimensions

Designation	Area A	Depth d	Web			Flange				Distance		Grip	Max. Flge. Fastener
			Thickness t_w		$\frac{t_w}{2}$	Width b_f		Average Thickness t_f		T	k		
	In.^{2}	In.	In.		In.	In.		In.		In.	In.	In.	In.
MC 9×25.4	7.47	9.00	0.450	7/16	1/4	3.500	3½	0.550	9/16	6⅝	1 3/16	9/16	⅞
×23.9	7.02	9.00	0.400	⅜	3/16	3.450	3½	0.550	9/16	6⅝	1 3/16	9/16	⅞
MC 8×22.8	6.70	8.00	0.427	7/16	3/16	3.502	3½	0.525	½	5⅝	1 3/16	½	⅞
×21.4	6.28	8.00	0.375	⅜	3/16	3.450	3½	0.525	½	5⅝	1 3/16	½	⅞
MC 8×20	5.88	8.00	0.400	⅜	3/16	3.025	3	0.500	½	5¾	1⅛	½	⅞
×18.7	5.50	8.00	0.353	⅜	3/16	2.978	3	0.500	½	5¾	1⅛	½	⅞
MC 8× 8.5	2.50	8.00	0.179	3/16	1/16	1.874	1⅞	0.311	5/16	6½	¾	5/16	⅝
MC 7×22.7	6.67	7.00	0.503	½	¼	3.603	3⅝	0.500	½	4¾	1⅛	½	⅞
×19.1	5.61	7.00	0.352	⅜	3/16	3.452	3½	0.500	½	4¾	1⅛	½	⅞
MC 7×17.6	5.17	7.00	0.375	⅜	3/16	3.000	3	0.475	½	4⅞	1 1/16	½	¾
MC 6×18	5.29	6.00	0.379	⅜	3/16	3.504	3½	0.475	½	3⅞	1 1/16	½	⅞
×15.3	4.50	6.00	0.340	5/16	3/16	3.500	3½	0.385	⅜	4¼	⅞	⅜	⅞
MC 6×16.3	4.79	6.00	0.375	⅜	3/16	3.000	3	0.475	½	3⅞	1 1/16	½	¾
×15.1	4.44	6.00	0.316	5/16	3/16	2.941	3	0.475	½	3⅞	1 1/16	½	¾
MC 6×12	3.53	6.00	0.310	5/16	⅛	2.497	2½	0.375	⅜	4⅜	13/16	⅜	⅝

American Institute of Steel Construction

APPENDIX 3

PIPE DIMENSIONS AND WEIGHTS

STAINLESS
CARBON & ALLOY
ALUMINUM
NICKEL

Pipe Size	O.D. in Inches	Pipe Schedules																	
		5s	5	10s	10	20	+	30	40s & STD	40	⊕	60	80s & E.H.	80	100	120	140	160	DBL E.H.
⅛	.405		.035 .1383	.049 .1863	.049 .1863				.068 .2447	.068 .2447 .0850			.095 .3145	.095 .3145 .1090					
¼	.540		.049 .2570	.065 .3297	.065 .3297				.088 .4248	.088 .4248 .1470			.119 .5351	.119 .5351 .1850					
⅜	.675		.049 .3276	.065 .4235	.065 .4235				.091 .5676	.091 .5676 .1960			.126 .7388	.126 .7388 .2560					
½	.840	.065 .5383	.065 .5383 .1860	.083 .6710	.083 .6710 .2320				.109 .8510	.109 .8510 .2940			.147 1.088	.147 1.088 .3760				.187 1.304 .4510	.294 1.714
¾	1.050	.065 .6838	.065 .6838 .2370	.083 .8572	.083 .8572 .2970				.113 1.131	.113 1.131 .3910			.154 1.474	.154 1.474 .5100				.218 1.937 .6700	.308 2.441
1	1.315	.065 .8678	.065 .8678 .3000	.109 1.404	.109 1.404 .4860				.133 1.679	.133 1.679 .5810			.179 2.172	.179 2.172 .7510				.250 2.844 .9840	.358 3.659
1¼	1.660	.065 1.107	.065 1.107 .3830	.109 1.806	.109 1.806 .6250				.140 2.273	.140 2.273 .7860			.191 2.997	.191 2.997 1.037				.250 3.765 1.302	.382 5.214
1½	1.900	.065 1.274	.065 1.274 .4410	.109 2.085	.109 2.085 .7210				.145 2.718	.145 2.718 .9400			.200 3.631	.200 3.631 1.256				.281 4.859 1.681	.400 6.408
2	2.375	.065 1.604	.065 1.604 .5550	.109 2.638	.109 2.638 .9130				.154 3.653	.154 3.653 1.264			.218 5.022	.218 5.022 1.737				.344 7.462 2.575	.436 9.029
2½	2.875	.083 2.475	.083 2.475 .8560	.120 3.531	.120 3.531 1.221				.203 5.793	.203 5.793 2.004			.276 7.661	.276 7.661 2.650				.375 10.01 3.464	.552 13.70
3	3.500	.083 3.029	.083 3.029 1.048	.120 4.332	.120 4.332 1.498				.216 7.576	.216 7.576 2.621			.300 10.25	.300 10.25 3.547				.438 14.32 4.945	.600 18.58

■	WALL THICKNESS IN INCHES
🟦	STEEL WEIGHT PER FOOT IN POUNDS
▩	ALUMINUM WEIGHT PER FOOT IN POUNDS

(continued)

Pipe Size	O.D. in Inches	Pipe Schedules (Continued)																	
		5s	5	10s	10	20	+	30	40s & STD	40	⊕	60	80s & E.H.	80	100	120	140	160	DBL E.H.
3½	4.000	.083 3.472	.083 3.472 1.201	.120 4.937	.120 4.937 1.720				.226 9.109	.226 9.109 3.151			.318 12.51	.318 12.51 4.326					.636 22.85
4	4.500	.083 3.915	.083 3.915 1.354	.120 5.613	.120 5.613 1.942				.237 10.79	.237 10.79 3.733			.337 14.98	.337 14.98 5.183		.438 19.00 6.560		.531 22.51 7.786	.674 27.54
4½	5.000								2.47 12.54				.355 17.61						
5	5.563	.109 6.349	.109 6.349 2.196	.134 7.770	.134 7.770 2.688				.258 14.62	.258 14.62 5.057			.375 20.78	.375 20.78 7.188		.500 27.04 9.353		.625 32.96 11.40	.750 38.55
6	6.625	.109 7.585	.109 7.585 2.624	.134 9.290	.134 9.289 3.213				.280 18.97	.280 18.97 6.564			.432 28.57	.432 28.57 9.884		.562 36.39 12.59		.719 43.35 15.67	.864 53.16
7	7.625								.301 23.54				.500 38.04						.875 63.08
8	8.625	1.09 9.914	1.09 9.914 3.429	.148 13.40	.148 13.40 4.635	.250 22.36 7.735	.175 5.463	.277 24.70 8.543	.322 28.55	.322 28.55 9.878		.406 35.64 12.33	.500 43.39	.500 43.39 15.01	.594 50.95 17.60	.719 60.71 20.97	.812 67.76 23.44	.906 74.79 25.84	.875 72.42
9	9.625								.342 33.91				.500 48.73						
10	10.75	.134 15.19	.134 15.19 5.256	.165 18.65	.165 18.70 6.453	.250 28.04 9.698	.279 10.79	.307 34.24 11.34	.365 40.48	.365 40.48 14.00		.500 54.74 18.93	.500 54.74	.594 64.43 22.25	.719 77.03 26.61	.844 82.29	1.000 104.1	1.125 115.6	1.000 104.1
11	11.75								.375 45.56				.500 60.08						
12	12.75	.156 21.07	.165* 22.18	.180 24.16	.180 24.16 8.359	.250 33.38 11.55	.375 17.14	.330 43.77 15.14	.375 49.56	.406* 53.52 18.52	.500 22.63	.562 73.15 25.31	.500 65.42	.688* 88.63 30.62	.844 107.3	1.000 125.5	1.125 136.7	1.312 160.3	1.000 125.5
14	14.00	.156 23.07		.188 27.73	.250 36.71	.312 45.61		.375 54.57	.375 54.57	.438 63.44		.594 85.05	.500 72.09	.750 106.1	.938 130.9	1.094 150.8	1.250 170.2	1.406 189.1	
16	16.00	.165 27.90		.188 31.75	.250 42.05	.312 52.27		.375 62.58	.375 62.58	.500 82.77		.656 107.5	.500 82.77	.844 136.6	1.031 164.8	1.219 192.4	1.438 223.6	1.594 245.3	

(continued)

Pipe Size	O.D. in Inches	Pipe Schedules (Concluded)																	
		5s	5	10s	10	20	+	30	40s & STD	40	⊕	60	80s & E.H.	80	100	120	140	160	DBL E.H.
18	18.00	.165 31.43		.188 35.76	.250 47.39	.312 58.94		.438 82.15	.375 70.59	.562 104.7		.750 138.2	.500 93.45	.938 170.9	1.156 208.0	1.375 244.1	1.562 274.2	1.781 308.5	
20	20.00	.188 39.78		.218 46.05	.250 52.73	.375 78.60		.500 104.1	.375 78.60	.594 123.1		.812 168.4	.500 104.1	1.031 208.9	1.281 256.1	1.500 296.4	1.750 341.1	1.969 379.2	
24	24.00	.218 55.37		.250 63.41	.250 63.41	.375 96.42		.562 140.7	.375 94.62	.688 171.3		.969 238.4	.500 125.5	1.219 296.6	1.531 367.4	1.812 429.4	2.062 483.1	2.344 542.1	
26	26.00				.312 85.60	.500 136.17			.375 102.63				.500 136.17						
28	28.00				.312 92.26	.500 146.85		.625 182.73	.375 110.64										
30	30.00	.250 79.43		.312 98.93	.312 98.93	.500 157.53		.625 196.08	.375 118.65				.500 157.53						
32	32.00				.312 105.59	.500 168.21		.625 209.43	.375 126.66	.688 230.08			.500 168.21						
34	34.00				.312 112.25	.500 178.89		.625 222.78	.375 134.67	.688 244.77									
36	36.00				.312 118.92			.625 236.13	.375 142.68	.750 282.35			.500 189.57						

Factors applicable to other products.

For nickel and alloy produced to these pipe sizes apply these factors to the blue numbers.

Nickel 200	1.1343	Monel 400	1.1272
Nickel 201	1.1378	Inconel 600	1.0742
Incoloy* 800	1.0247	Incoloy 825	1.0389

For aluminum TUBING produced to the listed pipe sizes—apply these factors for each grade.

1100 Wt. as shown	**2024** Wt. times 1.02
6061 Wt. as shown	**3003** Wt. times 1.01
6063 Wt. as shown	**5086** Wt. times .98
2014 Wt. times 1.03	**7075** Wt. times 1.03

COLUMNS + and ⊕ ARE WALL THICKNESS PRODUCED TO PIPE TOLERANCES

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APPENDIX 4

TABLE CONVERSION OF PIPE SIZES TO METRIC

U.S. Customary Units		**SI (Metric) Units**	
Nominal Pipe Size (NPS)	Outside Diameter (in.)	Diameter Number (DN)	Outside Diameter (mm)
1/8	0.405	3	10.3
1/4	0.540	6	13.7
3/8	0.675	10	17.1
1/2	0.840	15	21.3
3/4	1.050	20	26.7
1	1.315	25	33.4
1 1/4	1.660	30	42.2
1 1/2	1.900	40	48.3
2	2.375	50	60.3
2 1/2	2.875	65	73.0
3	3.500	80	88.9
3 1/2	4.000	90	101.6
4	4.500	100	114.3
5	5.563	125	141.3
6	6.625	150	168.3
8	8.625	200	219.1
10	10.75	250	273.0
12	12.75	300	323.8
14	14.00	350	355.6
16	16.00	400	406.4
18	18.00	450	457
20	20.00	500	508
24	24.00	600	601

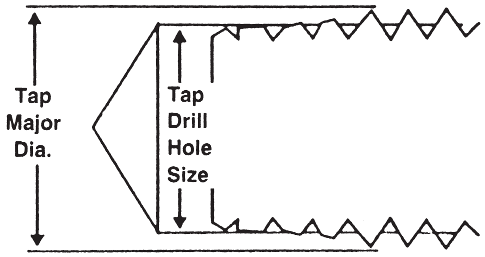
Courtesy: (ASME) American Society of Mechanical Engineers.

APPENDIX 5
DRILL DIMENSION CHART

The NC and NF tables recommend tap drills that result in approximately 75% thread height based upon drill diameter. In most materials, however, drills will produce a hole slightly larger than the drill diameter.

The tables list actual thread height percentages resulting from the probable hole size each drill will cut.

Thread heights over 60% of thread do not increase the strength of a threaded joint.



Machine Screw Sizes NC & NF

Nom. Size Tap	Recommended Tap Drill		Probable Hole Size	Actual % Thread
	Drill	Decimal		
0–80	3/64	.0469	.0484	71
1–64	53	.0595	.0610	59
1–72	53	.0595	.0610	67
2–56	50	.0700	.0717	62
2–64	50	.0700	.0717	70
3–48	47	.0785	.0804	69
3–56	46	.0810	.0829	69
4–40	43	.0890	.0910	65
4–48	3/32	.0938	.0958	60
5–40	38	.1015	.1038	65
5–44	37	.1040	.1063	63
6–32	36	.1065	.1091	71
6–40	33	.1130	.1156	69
8–32	29	.1360	.1389	62
8–36	29	.1360	.1389	70
10–24	26	.1470	.1502	74
10–32	21	.1590	.1622	68
12–24	16	.1770	.1805	66
12–28	15	.1800	.1835	70
..	..	..	..	..

Fractional Sizes NC & NF

Nom. Size Tap	Recommended Tap Drill		Probable Hole Size	Actual % Thread
	Drill	Decimal		
¼–20	7	.2010	.2048	70
¼–28	3	.2130	.2168	72
5/16–18	F	.2570	.2608	72
5/16–24	I	.2720	.2761	67
⅜–16	5/16	.3125	.3189	72
⅜–24	Q	.3320	.3364	71
7/16–14	U	.3680	.3726	70
7/16–20	25/64	.3906	.3952	65
½–13	27/64	.4219	.4266	73
½–20	29/64	.4531	.4578	65
9/16–12	31/64	.4844	.4892	68
9/16–18	33/64	.5156	.5204	58
⅝–11	17/32	.5313	.5362	75
⅝–18	37/64	.5781	.5831	58
¾–10	21/32	.6563	.6613	68
¾–16	11/16	.6875	.6925	71
⅞–9	49/64	.7656	.7708	72
⅞–14	13/16	.8125	.8177	62
1–8	⅞	.8750	.8809	73
1–12	59/64	.9219	.9279	67

Taper Pipe Taps

Nominal Size	Tap Drill	
	NPT	NPTF
1/16–27	D	D
⅛–27	Q	R
¼–18	7/16	7/16
⅜–18	9/16	37/64
½–14	45/64	45/64
¾–14	29/32	59/64
1–11½	1 9/64	1 5/32
1¼–11½	1 31/64	1½
1½–11½	1 47/64	1 47/64
2–11½	2 13/64	2 7/32
2½–8	2⅝	2 41/64
3–8	3¼	3 17/64

Straight Pipe Taps

Nominal Size	Tap Drill	
	NPS	NPSF
1/16–27	¼	¼
⅛–27	11/32	11/32
¼–18	7/16	7/16
⅜–18	37/64	37/64
½–14	23/32	23/32
¾–14	59/64	59/64
1–11½	1 5/32	1 5/32
1¼–11½	1½	1½
1½–11½	1¾	1¾
2–11½	2 7/32	2 7/32

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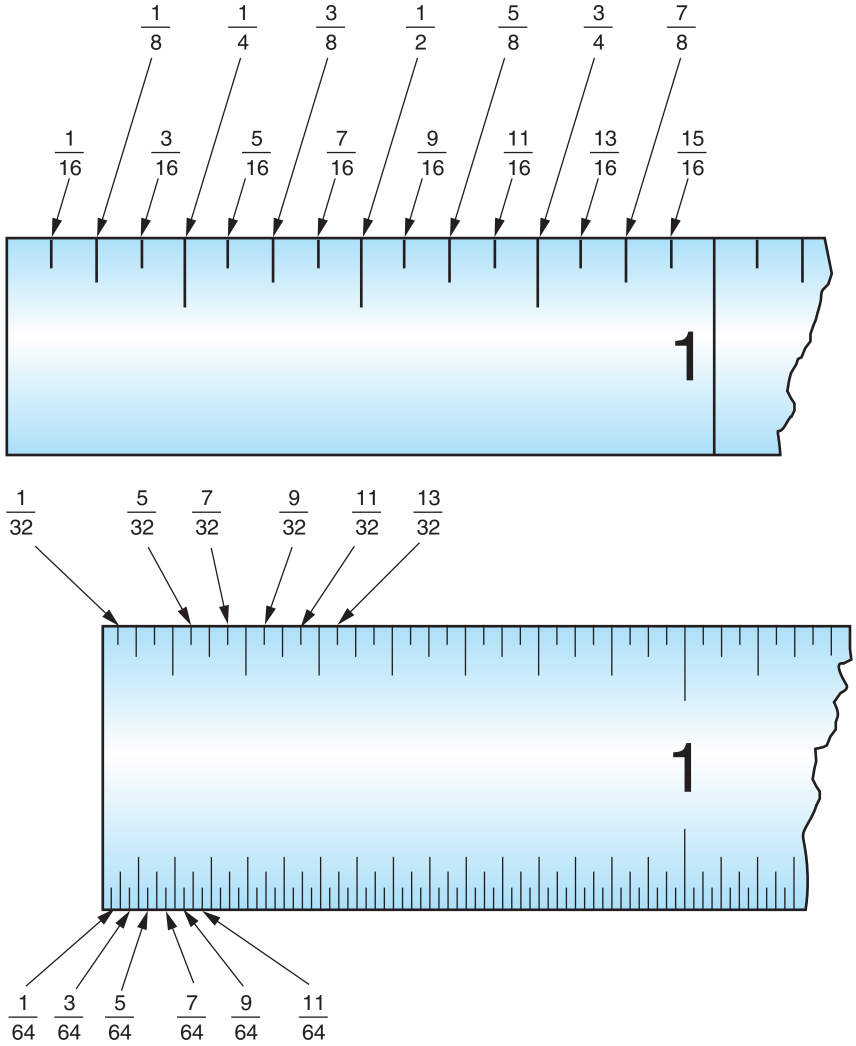
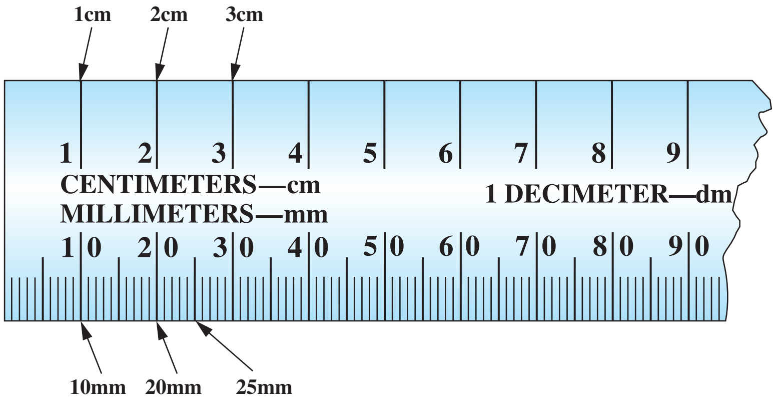
APPENDIX 6

STEEL RULE DIAGRAMS

Note: Not to scale.



British Standard Ruler (common fractions)



Metric Ruler (millimeters)

APPENDIX 7

METRIC THREADS—FINE AND COARSE

Metric Thread

Thread Nom. Dia. mm	Pitch mm	T.P.I.	Tapping Drill mm	Thread Nom. Dia mm	Pitch mm	T.P.I.	Tapping Drill mm
M 1	.25	102	.75	M 14	.25	12½	12
M 1.2	.25	102	.95	M 14 × 1.5	1.5	17	12.5
M 1.4	.3	85	1.1	M 14 × 1.25	1.25	20	12.8
M 1.6	.35	72½	1.25	M 15	2	12½	13
M 1.7	.35	72½	1.35	M 16	2	12½	14
M 1.8	.35	72½	1.45	M 16 × 1.5	1.5	17½	14.5
M 2	.4	63½	1.6	M 18	2.5	10	15.5
M 2.2	.45	56½	1.75	M 18 × 1.5	1.5	17	16.5
M 2.3	.4	63½	1.9	M 20	2.5	10	17.5
M 2.5	.45	56½	2.05	M 20 × 1.5	1.5	17	18.5
M 2.6	.45	56½	2.15	M 22	2.5	10	19.5
M 3	.5	51	2.5	M 22 × 1.5	1.5	17	20.5
M 3.5	.6	42	2.9	M 24	3	8½	21
M 4	.7	36	3.3	M 24 × 2	2	12½	22
M 4.5	.75	34	3.7	M 24 × 1.5	1.5	17	22.5
M 5	.8	32	4.2	M 27	3	8½	24
M 6	1	25½	5	M 27 × 2	2	12½	25
M 6 × .75	.75	34	5.25	M 27 × 1.5	1.5	17	25.5
M 7	1	25½	6	M 30	1	7¼	26.5
M 8	1.25	20	6.8	M 30 × 2	1.25	12½	28
M 8 × 1	1	25½	7	M 30 × 1.5	1	17	28.5
M 8 × .75	.75	34	7.2	M 33	3.5	7¼	29.5
M 9	1.25	20	7.8	M 33 × 2	2	12½	31
M 10	1.5	17	9.5	M 36 × 1.5	1.5	17	31.5
M 10 × 1.25	1.25	20	8.8	M 36	4	6	32
M 10 × 1	1	25½	9	M 36 × 3	3	8½	33
M 11	1.5	17	9.5	M 36 × 1.5	1.5	17	34.5
M 12	1.75	14½	10.2	M 39	4	6	35
M 12 × 1.5	1.5	17	10.5	M 39 × 3	3	8½	36
M 12 × 1.25	1.25	20	10.8	M 39 × 1.5	1.5	17	37.5

APPENDIX 8

COMPUTER GLOSSARY

Address window When connected to the Internet, this window, located at the top of the screen, tells you what site or address on the Internet you are visiting.

Browser A program for navigating the World Wide Web. Two examples are Netscape Navigator and Microsoft Internet Explorer.

Click To rapidly press and release the left mouse button one time.

Cursor An onscreen marker that shows you where in the document your typing will appear.

Database An organized, electronically-stored collection of related information. It can be searched and easily managed and updated.

Desktop An online work area that displays icons.

Double click To press the mouse button twice in rapid succession. Generally, double clicking is needed only when opening a computer program.

Drop-down list An onscreen list of options from which you can select one command.

E-mail Electronic mail; messages sent to people via computer.

Hardware The physical parts of the personal computer, such as the keyboard and the screen.

Hyperlink A small picture or icon, or highlighted text. Clicking on the hyperlink moves you to another document.

Icon A picture that represents a file, drive, or command.

Insertion point A vertical, blinking, onscreen marker that shows you where in the document your typing will appear.

Internet A worldwide network of computers linked to share information.

Keyboard A device used to communicate with computers. When a key is pressed, a signal or command is sent to the computer.

Laptop A small computer that is light enough to carry. Notebook computers and subnotebooks are even lighter.

Link See *Hyperlink*.

Location window See *Address window.*

Menu A list of commands or instructions displayed onscreen. Menus organize commands and make a program easier to use.

Menu bar An area, usually at the top of the screen, that contains several menus.

Monitor A television-like screen on which the computer displays information.

Mouse A handheld device with buttons on its upper surface. When rolled across a hard surface, it moves the pointer across the screen. When the buttons are clicked, signals and commands are sent to the computer.

Online Your computer is connected, turned on, and ready to use, accept, and/or send information.

Personal computer (PC) A small computer system equipped with the software and devices needed to perform computer operations.

Screen See *Monitor.*

Screen saver A program that replaces the screen display with a preselected image or picture if you haven't used your keyboard or mouse for a set period of time.

Scroll To move text or images vertically or horizontally onscreen by manipulating the scroll bars with a mouse.

Scroll bar A vertical or horizontal strip that appears at the right and/or bottom sides of a window and when manipulated with a mouse moves or scrolls the image up and down or left and right.

Search engine Programs that help you find and retrieve information on the Internet. Examples are www.google.com and www.lii.org (librarians' guide to the Internet).

Software Computer programs that either help operate the computer or perform tasks.

Taskbar The bar, usually at the bottom of a window, that includes the Start button and buttons for the windows you currently have open.

Title bar A bar at the very top of a window that contains the title of the program or document you are using.

Toolbar A row of command buttons near the top of a window.

URL (Uniform Resource Locator) The address for an Internet site.

Web address See *URL*.

Window A rectangular area of the screen that a program uses to display information.

Windows A popular line of operating system software.

World Wide Web (a.k.a. WWW or Web) A part of the Internet that consists of documents interconnected by links. To move from one document to another, you click a link.

APPENDIX 9
GLOSSARY—ENGLISH-SPANISH

Area of revolution As applied to the testing of welded objects, an area of revolution specifies a multi-sided portion of a part or object to be tested. The area to be tested is indicated by the examine-all-around symbol, with or without a length dimension, depending upon the extent of the area to be examined. When a length dimension is applied to a testing symbol with an examine-all-around symbol, it signifies that only a particular length of the area of revolution is to be examined.

Área de revolución Un área de revolución, en el contexto de su aplicación a probar objetos soldados, identifica una porción de múltiples lados de una parte u objeto que debe ser probado. El área que debe ser probado se indica por medio del símbolo de "probar todo alrededor," que tenga o no una dimensión de longitud, dependiendo de lo extendido de la parte que debe ser probada. Cuando un símbolo de probar, que contiene un símbolo de probar todo alrededor, incluye una dimensión de longitud, esto significa que sólo una longitud determinada del área de revolución debe ser examinada.

Arrow One component of a welding symbol on a plan or view. The arrow is always drawn at an angle to the reference line. Multiple arrows may be added to the reference line to show the same weld in several different locations (i.e., a group of spot or fillet welds). When the arrow is shown with a break, the break is made toward the member of the joint that is to be prepared or shaped. If there is no instruction as to which joint member is to be prepared, the arrow need not be shown with a break.

Flecha Un componente de un símbolo de soldadura en un plano o una vista. La flecha siempre está dibujado a un ángulo a la línea de referencia. Múltiples flechas pueden ser añadidas a la línea de referencia para indicar la misma soldadura en varias ubicaciones diferentes (es decir, un grupo de soldaduras de filete). Al mostrar la flecha con un brecha, la brecha se coloca hacia el miembro de la junta que debe ser preparado o formado. Si no se indica cual miembro de la junta ha de ser preparado, se puede mostrar la flecha sin brecha.

Arrow side The lower side of a reference line in a welding symbol. Refers to the location of the weld with respect to the joint. When the weld symbol for plug or slot welds is located on the arrow side of the reference line, the hole is in the arrow side member of the joint.

Lado de flecha El lado inferior de una línea de referencia en un símbolo de soldadura. Se refiere a la ubicación de la soldadura con relación a la junta. Cuando el símbolo de soldadura para soldaduras de tapón o ranura se encuentra en el lado de flecha de la línea de referencia, el agujero está en el lado de flecha del miembro de la junta.

Auxiliary view An optional view of a slanted (oblique) surface from a position at right angles (90° perpendicular) to it, allowing the surface to be shown in its true size and shape (in any other view, this surface is distorted or foreshortened). The development of the auxiliary view is sometimes shown by lines projected perpendicularly from the slanted surface. Usually, only that part of the view that represents the slanted surface is shown.

Vista auxiliar Una vista opcional de una superficie inclinada (oblicua) desde una posición de ángulo recto (90° perpendicular) a ella, que permite mostrar la superficie en su verdadero tamaño y forma (de cualquier otra vista, esta superficie se distorsiona o escorza). A veces, se muestra el desarrollo de la vista auxiliar por líneas que se proyectan de manera perpendicular desde la superficie inclinada. Por lo general, sólo se muestra aquella parte de la vista que representa la superficie inclinada.

Baseline Object line that usually represents a machined surface. Baselines may also originate from centerlines.

Línea de base Línea de objeto que por lo general representa una superficie trabajada a máquina. También , las líneas de base pueden originar de líneas de centro.

Baseline dimensioning A method of dimensioning in which all dimensions originate from baselines. In this method, dimensions are normally expressed as three-place decimals. Commonly used to dimension precision parts. Since, with baseline dimensioning, calculations are not required to find a dimension, cummulative errors do not occur.

Dimensionamiento de línea de base Un método para dimensionar en el cual todas las dimensiones se originan de líneas de base. En este método, las dimensiones se expresan normalmente como decimales en milésimas. Por lo general se utilizan para dimensionar piezas de precisión. Desde que el usar dimensionamiento de línea de base no se requiere hacer un cálculo para determinar una dimensión, no se producen errores cumulativos.

Basic dimension Found in both GDT and coordinate drawings, this dimension is enclosed in a square. It is considered to be an exact dimension to which tolerance values are applied.

Dimensión básica utilizada en dibujos tanto de GDT (dimensionamiento y tolerancia geométrica) como de coordenados, esta dimensión se encierra en una casilla. Se considera una dimensión exacta a la cual se aplican los valores de tolerancia.

Bevel Describes an edge preparation with a sharp or "feather" edge or with a root face or "land." Machinists make a clear distinction between bevel and chamfer, but weld fabricators often simply apply the term "bevel" to both. When a bevel or J-groove weld symbol (either single or double) is used, the arrow will point with a definite break toward the member to be shaped.

Bisel Describe la preparación de un borde como liso o "difuminado" o con una cara de raíz o de "terreno." Los maquinistas fijan una distinción clara entre el biselado y el achaflanado, pero con frecuencia los fabricantes de soldaduras simplemente aplican el término "bisel" a ambos. Cuando se utiliza un símbolo de bisel o de ranura de J (ya sea simple o doble), la flecha señala con una brecha definida al miembro que debe ser formado.

Bracket One of two widely used methods to distinguish U.S. Customary (inch) units from the Systems Internationale (metric) units when dual dimensions are applied to a drawing. With the bracket method, either the inch or the metric dimension is enclosed in brackets. A notation on the drawing indicates which units are enclosed in brackets. Either the positioning method or the bracket method may be used in a drawing but not both. The method used is indicated by a note on the drawing.

Corchete Uno de dos métodos comúnmente utilizados para distinguir las unidades del sistema de medidas de los Estados Unidos (pulgadas) de las unidades del Sistema Internacional (métrico) cuando se aplican dimensiones dobles en un dibujo. Con el método de los corchetes, o la dimensión de las pulgadas o la métrica se encierra entre corchetes. Una notación en el dibujo indica cual de las unidades se encierra en corchetes. Se puede utilizar o el método de posicionamiento o el de corchetes en un dibujo, pero no los dos. El método utilizado se indica por medio de una nota en el dibujo.

Break symbol A symbol used to indicate that a section of metal has been removed from or not included in the view. There are several commonly used conventional break symbols. (These symbols are shown in Figure 7.1.)

Símbolo de quebrado Un símbolo utilizado para indicar que una sección de metal ha sido retirada de la vista o no incluida en la misma. Existen varios símbolos convencionales de quebrada que se utilizan comunmente. (Estos símbolos se ven en la Figura 7.1).

Callout An identification, usually a number, applied to each of the parts on an assembly drawing. Each identification is referenced to a bill of materials that contains the information needed to produce each part.

Subtítulo una identificación, por lo general un número, aplicada a cada una de las partes de un dibujo de montaje. Cada identificación tiene una referencia a una lista de materiales que contiene los datos requeridos para producir cada parte.

CJP (complete joint penetration) A notation found in the tail of the arrow of a welding symbol which indicates that, no matter what type of weld or joint preparation is used, a complete joint penetration weld is required.

CJP (*penetración completa de la junta*) Una notación encontrada en la punta final de una flecha de un símbolo de soldadura, la cual indica que, sin importar qué clase de preparación de soldadura o de junta se utilice, se requiere una soldadura de penetración completa de la junta.

Cold-rolled The name of a process by which steel is formed during the final stages of manufacture. Cold-rolled steels have square corners and are more precisely sized than hot-rolled steels.

Laminado en frío El nombre de un proceso por el cual se forma el acero durante las etapas finales de fabricación. Los aceros laminados en frío tienen esquinas cuadradas y medidas más precisas que los aceros laminados con calor.

Contour The shape of the weld face. A supplementary contour symbol is used with the weld symbol to specify the shape of the face of the weld. The symbol is placed on the same side of the reference line as the weld symbol. It is located directly above the weld symbol when the weld symbol is placed on the other side of the reference line, and directly below the weld symbol when the weld symbol is located on the arrow side of the reference line. May be supplemented by a finish symbol.

Contorno La forma de la cara de la soldadura. Un símbolo complementario de contorno se utiliza con el símbolo de soldadura para identificar la forma de la cara de la soldadura. El símbolo se coloca en el mismo lado de la línea de referencia que el símbolo de soldadura. Se ubica directamente encima del símbolo de soldadura cuando el mismo es colocado al otro lado de la línea de referencia, y directamente debajo del símbolo de soldadura cuando el mismo es colocado al lado de la flecha de la línea de referencia. Puede ser complementado con un símbolo de terminado.

Conventional dimensioning A method of dimensioning in which the overall dimensions of length, width, and height are given.

Dimensionamiento convencional Un método para dimensionar en el cual se dan las dimensiones globales de largo, ancho y alto.

Coordinate A standard used for dimensioning orthographic drawings. The coordinate standard has been widely replaced by the GDT standard.

Coordinada Un estándar utilizado para dimensionar los dibujos ortográficos. Por lo general, el estándar coordinado ha sido reemplazado por el estándar GDT (dimensionamiento y tolerancia geométrica).

Cutting plane The extent of the cut surface of a full section or cross section view of an object. The position of the cutting plane is shown by a cutting plane line located on one of the principal views. This line indicates the direction from which the principal view is to be viewed to derive the section. In addition, the line indicates where the section is located with relation to the principal view. The cutting plane line is composed of long dashes alternating with a pair of short dashes.

Plano de corte La parte de una superficie cortada de un objeto, sea de una sección completa o de una vista transversal. La posición del plano de corte se muestra por una línea de plano de corte, ubicada en una de las vistas principales. Esta línea indica la línea de vista principal para derivar la sección. Además, la línea indica la ubicación de la sección con relación a la vista principal. La línea del plano de corte se compone de guiones largos que alternan con un par de guiones cortos.

Datum feature Under GDT standards for dimensioning orthographic drawings, a datum feature is any feature of a part, such as a surface, plane, or hole. The datum feature symbol is a special symbol used in GDT drawings.

Rasgo de dato Bajo el estándar GDT (dimensionamiento y tolerancia geométrica) para dimensionar dibujos ortográficos, un rasgo de dato es cualquier rasgo de una parte tal como una superficie, plano o agujero. El símbolo de rasgo de dato es un símbolo especial utilizado en los dibujos de GDT.

Depth of filling Indicates the quantity of material required in the finished weld hole. When shown, the depth of filling will be provided within the symbol for both plug and slot welds. When depth of filling is not shown, complete filling is required.

Profundidad de relleno Indica la cantidad de material requerido para llenar el agujero con soldadura. Cuando se indica, la profundidad de relleno se proporciona dentro del símbolo para la soldadura de tapón así como la de ranura. Cuando no se indica la profundidad de relleno, quiere decir que se requiere un relleno completo.

Developed view A view of a part as it appears when stretched or laid out on a flat surface. This view shows the part before it is shaped by bending, rolling, or other fabrication methods. It illustrates the part exactly as it must be prepared before any bending or rolling is performed. It is common practice to show the location of any bends on this view. The dimensions shown on the developed view include any allowances necessary for bending or rolling. Also called a development.

Vista desarrollada La apariencia de una parte cuando está tirada o colocada en una superficie plana. Muestra la parte antes que sea formada mediante ser doblada, roldeada u otro método de fabricación. Muestra exactamente como la parte debe ser preparada antes que se haga cualquier doblaje o laminado. La práctica convencional es mostrar la ubicación de cualquier doblez en esta vista. Las dimensiones indicadas en la vista desarrollada incluyen cualquier tolerancia necesaria para el doblaje o laminado. También se conoce como un desarrollo.

Dual dimensioning The application of both U.S. Customary and metric units (usually in millimeters) of measurement on a drawing. This method is used to permit the manufacture of parts in either unit of measurement, depending on their application and/or where they will be marketed.

Dimensionamiento doble La aplicación en un dibujo de la medida de unidades convencionales de los Estados Unidos así como de unidades métricas (por lo general en milímetros). Este método se utiliza para fabricar partes en cualquiera de las dos unidades de medida, que depende de su aplicación y/o en dónde serán puestas a la venta.

Enlarged detail A portion of a print, usually of a part or portion of a part, provided in enlarged scale to more clearly present details about dimensions and to make it easier to interpret the details of the area shown. Each enlarged detail is identified by a letter or number that corresponds to the letter or number used to identify the point on a principal view to which the detail refers.

Detalle ampliado Una porción de una impresión, por lo general una parte o una porción de una parte, dada en escala ampliada para presentar más claramente los detalles de las dimensiones, y para facilitar interpretar los detalles del área mostrado. Cada detalle ampliado se identifica por una letra o número que corresponde a una letra o número que identifica ese punto en una vista principal.

Faying A word designating the joining surfaces for a weld. Usually used in the phrase "faying surfaces." The term comes from the root word "fay," a verb that means to closely or precisely join or fit two things together.

Acoplamiento Una palabra que designa las superficies que deben unirse con una soldadura. Por lo general se utiliza en la frase "superficies de acoplamiento." El término se deriva de la palabra raiz "fay," un verbo que significa unir dos partes estrecha y precisamente.

Feather edge The full- or partial-length sharp edge of a slope or bevel imposed on a piece of metal to prepare it for welding to another piece of metal.

Borde difuminado El largo total o parcial de un borde afilado de una pendiente o bisel impuesto en un pedazo de metal para prepararlo para ser soldado a otro pedazo de metal.

Feature Under GDT standards for dimensioning orthographic drawings, a term applied to a part such as a surface, slot, or hole.

Característica Bajo los estándares GDT (dimensionamiento y tolerancia geométrica) para dimensionar dibujos ortográficos, un término que se aplica a una parte, tal como una superficie, ranura o agujero.

Feature of location Under GDT standards for dimensioning orthographic drawings, a feature of location is a size dimension that locates the centerlines of a circle or a centerline of a part in relation to another part.

Característica de ubicación Bajo los estándares GDT (dimensionamiento y tolerancia geométrica) para dimensionar dibujos ortográficos, una característica de ubicación es una dimensión de tamaño que ubica las líneas de centro de un círculo o una línea de centro de una parte con relación a otra parte.

Feature of size Under GDT standards for dimensioning orthographic drawings, a feature of size is a size dimension applied to a part that may be a circle, sphere, angle, or distance between two or more parallel surfaces.

Característica de tamaño Bajo los estándares GDT (dimensionamiento y tolerancia geométrica) para dimensionar dibujos ortográficos, una característica de tamaño es una dimensión de tamaño que se aplica a una parte que puede ser un círculo, una esfera, un ángulo, o una distancia entre dos o más superficies paralelas.

Filling, depth of, See *Depth of filling.*

Relleno, profundidad de Véase *Profundidad de relleno.*

Finish The final surface of a weld. The standard finish symbols are letter designations. They are used with contour symbols to specify the method used for forming the contour of a weld. The letter "C" is used for chipping, "G" for grinding, "M" for machining, "R" for rolling, "H" for hammering, and "U" for unspecified. Applying the letter "U" to a contour symbol signifies any method of finish may be used. In addition, a numerical degree of finish may be shown above the finish mark.

Terminado La superficie final de una soldadura. Los símbolos estándar de terminado son letras. Se utilizan con símbolos de contorno para identificar el método utilizado para formar el contorno de una soldadura. Se usa la letra "C" para astillar, "G" para triturar, "M" para trabajar a máquina, "R" para laminar, "H" para martillar, y "U" para especificaciones desconocidas. Aplicar la letra "U" a un símbolo de contorno significa que se puede utilizar cualquier método de terminado. Además, un grado numérico de terminado puede ser indicado encima del símbolo de terminado.

Flat bar Stock that does not exceed 63″ in width. Flat bar stock comes in many thicknesses; the length may vary from 18 to 22 feet.

Barra plana Cabezal que no excede las 63 pulgadas de ancho. El cabezal de barra plana viene en varios grosores; la longitud varía de 18 a 22 pies.

GDT (geometric dimensioning and tolerancing) standards The most current standard for dimensioning orthographic drawings. The majority of manufacturing companies and the military have adopted this standard. This standard incorporates the use of special geometric symbols, modifiers, and terms not found on coordinate dimensioned drawings.

Estándares GDT (dimensionamiento y tolerancia geométrica) El estándar más actualizado para dimensionar dibujos ortográficos. La mayoría de las compañías de fabricación y los militares han adoptado este estándar. Este estándar incorpora el uso de símbolos especiales geométricos, modificadores y términos que no se encuentran en dibujos de coordenadas dimensionadas.

Geometric characteristic symbols Symbols used in the GDT standard for dimensioning orthographic drawings. These symbols may be modified by geometric symbol modifiers.

Símbolos característicos geométricos Los símbolos utilizados en el estándar GDT (dimensionamiento y tolerancia geométrica) para dimensionar dibujos ortográficos. Estos símbolos pueden ser modificados por modificadores de símbolos geométricos.

Geometric symbol modifiers Marks used to modify geometric characteristic symbols in the GDT standard for dimensioning orthographic drawings.

Modificadores de símbolos geométricos Marcas utilizadas para modificar símbolos geométricos característicos en el estándar GDT (dimensionamiento y tolerancia geométrica) para dimensionar dibujos ortográficos.

Half section A view of an object which is imagined to be cut only halfway through (a one quarter section of the part). The cut portion is removed in this view so that the details of the cut surface can be viewed. The other half of the object is shown as it normally appears in the associated principal view. Half sections are used primarily to show the interior construction details of symmetrical parts. Section lines are used to indicate the imaginary cut surface of a half section in the same manner as for full sections.

Media sección Una vista de un objeto con cortes imaginarias que llegan únicamente a la mitad (una sección de un cuarto de la parte). En esta vista, se retira la porción cortada para poder estudiar los detalles de la superficie cortada. La otra parte del objeto muestra como se parece normalmente. Principalmente, se utilizan secciones medias para mostrar la construcción interior detallada de partes simétricas. Se ponen líneas en la superficie para indicar las cortes imaginarias de una media sección, en la misma manera que para secciones completas.

Hot-rolled The name of a process by which steel is formed during the final stages of manufacture. Steel that has been hot-rolled is slightly oversized and has slightly rounded corners.

Laminado con calor El nombre de un proceso por el cual se forma el acero durante las últimas etapas de fabricación. El acero que ha sido laminado con calor sobrepasa un poco el tamaño normal y tiene esquinas levemente redondeadas.

Imagined A mental or visual image. Usually associated with views (such as sections or cross sections) that show details of objects that cannot be seen in normal views. Imagined views do not reflect the depicted objects as the objects will be built. Rather, imagined views provide details that are needed or helpful during construction of the objects.

Imaginado/a Una visión mental o visual. Por lo general asociada con vistas (tales como de secciones o cortes transversales) que demuestran detalles de objetos que no se pueden ver en vistas normales. Las vistas imaginarias no muestran los objetos tal como serán construidos. Más bien, las vistas imaginarias proporcionan detalles que sean necesarios o provechosos durante la construcción del objeto.

Included angle The angle, shown in degrees and fractions of a degree, that describes the meeting of two lines when one line is at an angle to a horizontal, vertical, or another angular line. While the included angle is sometimes expressed in degrees and minutes (60° 30″), the decimal fraction for minutes is preferred.

Ángulo incluido El ángulo, mostrado en grados y fracciones de un grado, que describe la junta de dos líneas cuando una línea se encuentra a un ángulo de una línea horizontal, vertical o angular. Mientras que el ángulo incluido es a veces está expresado en términos de grados y minutos (60° 30″), se prefiere la fracción decimal por minutos.

Kilogram A measurement unit for weight used in the metric system. The metric system is the most widely used system of measurement in the world. A kilogram (kg) is 1000 grams or approximately 2.2046 pounds. It is widely known as a "kilo." A gram (g) is the basic unit of weight in the metric system and equals approximately 0.035 ounce

Kilogramo Una medida unitaria de peso, utilizada en el sistema métrico. El sistema métrico es el sistema de medidas de mayor uso en el mundo. Un kilogramo (kg) se compone de 1,000 gramos o aproximadamente 2.2046 libras. Esta medida es más conocida como un "kilo." Un gramo (g) es la unidad básica de peso en el sistema métrico y equivale a aproximadamente 0.035 onzas.

Land The root face area along the beveled edge of a piece of metal that has been prepared for welding.

Terreno La área de la cara de raíz a lo largo del borde biselado de un pedazo de metal que ha sido preparado para ser soldado.

Location The point on a print where metal has been removed or omitted from that view. Each location is indicated by break lines.

Ubicación El punto en un impresión donde el metal ha sido retirado u omitido de esa vista. Se indica cada ubicación por líneas con brechas.

Metal plate A piece of metal greater than 3/16″ in thickness and more than 6″ in width. Available in widths of up to 200 inches and lengths of up to 100 feet.

Placa metálica Un pedazo de metal mayor de 3/16 pulgadas de grosor y más de 6 pulgadas de ancho. Disponible en anchuras de 200 pulgadas o menos y en longitudes de 100 pies o menos.

Meter The basic measurement unit for length used in the metric system of measurement. Occasionally spelled "metre." The metric system is the most widely used system of measurement in the world.

A meter is based on the speed of light in a vacuum. It equals approximately 39.37 inches. Longer or shorter distances are indicated by a prefix added to the term. For example, a kilometer (km) is equal to 1000 meters (0.62 mile). A centimeter (cm) is 0.01 meter and equal to approximately 0.39 inch. A millimeter (mm) is 0.001 meter and equal to approximately 0.039 inch.

Metro La unidad básica de medida para longitud, utilizada en el sistema métrico de medidas. Ocasionalmente se escribe como “metre” en el idioma inglés. El sistema métrico es el sistema de medidas de mayor popularidad en el mundo. Un metro se basa en la velocidad de luz en un vacío. Aproximadamente equivale a 39.37 pulgadas. Distancias más largas o más cortas son indicadas por un prefijo añadido al término. Por ejemplo, un kilómetro (km) se equivale a 1,000 metros y es aproximadamente 0.62 millas. Un centímetro (cm) se equivale a 0.01 metros y es aproximadamente 0.39 pulgadas. Un milímetro (mm) se equivale 0.001 metros y es aproximadamente a 0.039 pulgadas.

Number The quantity of welds specified. The number of welds to be made is shown in parentheses below an arrow side of the plug and slot weld symbol or may be specified in the tail of the welding symbol.

Número La cantidad de soldaduras requeridas. El número de soldaduras hechas se indica entre paréntesis debajo del lado de la flecha del símbolo de soldadura de tapón o ranura, o se puede imprimir al final del símbolo de soldadura.

Other side The upper side of the reference line in a welding symbol. The term applies to the location of the weld with respect to the joint. When the weld symbol for plug or slot welds is located on the other side of the reference line, the hole is in the other side member of the joint.

Otro lado La parte superior de la línea de referencia en un símbolo de soldadura. El término se aplica a la ubicación de la soldadura con relación a la junta. Cuando el símbolo de soldadura para soldaduras de tapón o ranura se encuentra al otro lado de la línea de referencia, el agujero se encuentra en el otro miembro lateral de la junta.

Phantom section A view primarily used to show a mating part. The phantom section may or may not be shown in detail on the drawing. Its primary purpose is to show how the parts fit or operate together. A phantom section may also be used to illustrate the function of the object. This type of section is not dimensioned or shown in great detail. The shape (perimeter) of the phantom object and its alternate positions are shown through the use of short, thin dash lines.

Sección fantasma Una vista utilizada por lo general para ilustrar una pieza que cuadra. Puede que la sección fantasma se muestra de manera detallada en el dibujo o no. Su objetivo principal es el demostrar cómo las partes se encajan o funcionan juntas. También, puede que se utilice una sección fantasma para describir la función del objeto. Esta clase de sección no se muestra con las dimensionas ni con muchos detalles. La forma (perímetro) del objeto fantasma y sus posiciones alternativas se definen por líneas quebradas cortas y delgadas.

Plane area As applied to the testing of welded objects, the plane area specifies the portion of the part or object to be tested. It is shown circumscribed by a nondestructive examination symbol. Specific locations to be tested may be indicated by the locations of test symbols. Testing procedures to be used are indicated by the combining of examination symbols.

Área de plano Como se aplica a la prueba de objetos soldados, la área de plano identifica la porción de la pieza u objeto que debe ser probada. Se muestra circunscrita por un símbolo de evaluación no destructiva. Se pueden indicar ubicaciones específicas que deben ser probadas por símbolos de prueba. Se indican los procedimientos de prueba que se utilizarán con una combinación de símbolos de evaluación.

Plug weld A weld made through a round hole. Plug welds and slot welds are identified by the same symbol in the welding symbol, except that plug welds are not identified by a detail drawing in the tail of the welding symbol. When the weld symbol for a plug weld is located below the reference line, the hole is in the arrow side of the member joint. When the symbol is located above the reference line, the hole is in the other side member. The spacing (pitch) and depth of filling may also be specified in the welding symbol. When the sides of the plug weld hole are to be tapered, the included angle with a degree sign is applied to the symbol.

Soldadura de tapón Una soldadura ejecutada a través de una agujero redondo. Las soldaduras de tapón y las de ranura se identifican por el mismo símbolo en el símbolo de soldadura, salvo que las soldaduras de tapón no son identificadas por un dibujo detallado en la punta final del símbolo de soldadura. Cuando el símbolo de soldadura para una soldadura de tapón se encuentra debajo de la línea de referencia, el agujero está en el lado de flecha del miembro de la junta. Cuando el símbolo se encuentra encima de la línea de referencia, el agujero está en el otro miembro lateral. También, se puede indicar en el símbolo de soldadura el espacio (grado de inclinación) y la profundidad del relleno.

Cuando los lados del agujero de soldadura de tapón se disminuyen, se incluye en el símbolo el ángulo en grados.

Positioning One of two widely used methods to distinguish U.S. Customary (inch) units from the Systems Internationale (metric) units when dual dimensions are applied to a drawing. With the positioning method, the inch and metric dimensions are positioned in specific locations with respect to one another. The units are separated either by a horizontal line (usually a dimension line) or a slash line. Either the positioning method or the bracket method may be used in a drawing but not both. The method used is indicated by a note on the drawing.

Posicionamiento Uno de los dos métodos utilizados más comúnmente para distinguir las unidades convencionales de los Estados Unidos (pulgadas) y de las unidades del Sistema Internacional (métrico), cuando se aplican dimensiones dobles a un dibujo. Con el método de posicionamiento, las dimensiones de pulgadas y metros se ubican de manera específica con relación la una a la otra. Las unidades son separadas o por una línea horizontal (por lo general una línea de dimensión) o por una línea diagonal. Se puede usar en un dibujo o el método de posicionamiento o el método de corchetes, pero no los dos. El método utilizado se indica por una nota en el dibujo.

Radian The unit used to represent a plane angle, which is equal to 57.3°. Not often used on a drawing except in cases when it is essential that the Systems Internationale units be maintained throughout the drawing. In such cases, values of less than 57.3° are shown as decimal fractions of a radian.

Radián La unidad utilizada para representar un ángulo de plano, el cual equivale a 57.3°. No se utiliza mucho en dibujos salvo en casos en los cuales es esencial que las unidades del Sistema Internacional sean mantenidas en toda la ilustración. En tales casos, valores menores de 57.3° se muestran como fracciones decimales de un radián.

Reference dimension A dimension may be provided to expedite the reading of a drawing without the need for addition or subtraction of dimensions to obtain a size. It is not a required dimension. A reference dimension is enclosed in a parentheses on GDT and coordinate orthographic drawings.

Dimensión de referencia Se podría proporcionar una dimensión para facilitar la lectura de un dibujo en el cual no hay que sumar o restar dimensiones para obtener un tamaño. No es una dimensión requerida. Una dimensión de referencia se escribe entre paréntesis en los dibujos de ortográficas coordinadas o de GDT (dimensionamiento y tolerancia geométrica).

Reference line The foundation of a welding symbol. All the other information (including dimensions, weld specifications, and measurements) in a welding symbol is applied to the reference line. A reference line is always drawn horizontal to the bottom of the print.

Línea de referencia La base del símbolo de soldadura. Todos los demás datos (incluyendo dimensiones, especificaciones de soldadura y medidas) en un símbolo de soldadura se aplican a la línea de referencia. Una línea de referencia siempre se traza de manera horizontal, con relación a la parte inferior del impresión.

Revolved section A cross section view of a shape that has been turned (revolved) 90°. A revolved section can be placed in a space between break lines when break lines are used to indicate a reduced length or when the structural shape between break lines is not uniform in size. Occasionally, break lines may be used to indicate where the revolved section applies. Revolved sections are often used to aid print interpretation.

Sección girada Una vista del corte transversal de una forma que ha sido girado 90°. Se puede colocar una sección girada en un espacio entre líneas quebradas cuando las líneas quebradas indican una longitud reducida o cuando la forma estructural entre las líneas quebradas no es de tamaño uniforme. Ocasionalmente, se pueden utilizar líneas quebradas para indicar dónde se debe aplicar la sección girada. Frecuentamente, se usan las secciones giradas para facilitar la interpretación de impresión.

Sheet metal A piece of metal 3/16″ or less in thickness and more than 63″ in width. Available in widths up to 200 inches and lengths of up to 100 feet.

Metal laminado Un pedazo de metal de 3/16 pulgadas o menos en grosor y 6 pulgadas de ancho o más. Disponible en anchuras de 200 pulgadas o menos y en longitudes de 100 pies o menos.

Size A dimension. The size of a plug weld refers to its diameter in inches at the base of the weld. This dimension is located to the left of the weld symbol and is preceded by the diameter symbol.

Tamaño una dimensión El tamaño de una soldadura de tapón se refiere a su diámetro en pulgadas a la base de la soldadura. Esta dimensión se encuentra a la izquierda del símbolo de soldadura y sigue el símbolo de diámetro.

Sketch A freehand drawing used to describe the shape and size of an object. It is used to quickly express ideas, to provide rough drafts in advance of finished drawings, to express proportions and dimensions, and to make lines, arcs, circles, and ellipses, among other shapes. Often used in place of finished drawings, particularly when time and circumstances do not permit preparation of a finished drawing.

Croquis Un dibujo hecho a mano utilizado para describir la forma y tamaño de un objeto. Se utiliza para expresar ideas de manera rápida, para proporcionar borradores anteriores a los dibujos terminados, para mostrar proporciones y dimensiones y para hacer líneas, arcos, círculos y elipses, entre otras formas. Utilizados frecuentemente en lugar de dibujos terminados, especialmente cuando el tiempo y las circunstancias no permiten la preparación de dibujos terminados.

Slot weld A weld similar to a plug weld except that the shape of the hole is elongated rather than round. Slot welds are indicated by the same symbol used for plug welds except that a reference to a detail drawing is provided in the tail of the welding symbol. The detail drawing shows the shape, location, and orientation of the slot weld. When the weld symbol for a slot weld is located below the reference line, the hole is in the arrow side member of the joint. When the weld symbol is located above the reference line, the hole is located in the other side member. When the sides of the slot weld hole are to be tapered, the included angle with a degree sign is applied to the symbol. The width dimension of a slot weld is located to the left of the symbol and represents the width of the minor axis of the slot at its base.

Soldadura de ranura Una soldadura similar a una soldadura de tapón salvo que la forma del agujero es alargadoy no redondo. Se usa el mismo símbolo para indicar soldaduras de ranura y soldaduras de tapón salvo que una referencia a un dibujo detallado se escribe en la punta final del símbolo de soldadura. El dibujo detallado muestra la forma, ubicación y orientación de la soldadura de ranura. Cuando el símbolo de soldadura para una soldadura de ranura se ubica por debajo de la línea de referencia, el agujero se encuentra en el lado de flecha del miembro de la junta. Cuando el símbolo de soldadura se encuentra por encima de la línea de referencia, el agujero se ubica en el otro miembro lateral. Cuando los lados del agujero de la soldadura de ranura deben ser reducidos, se agrega al símbolo el ángulo con el símbolo de grados. La dimensión de lo ancho de la soldadura de ranura se encuentra a la izquierda del símbolo y representa la anchura del eje menor de la ranura a la base.

Spacing Also called pitch. This specifies the location of welds. For plug welds, this dimension is provided to the right of the plug weld symbol. In the case of slot welds, the spacing (pitch) dimension follows the length dimension and is preceded by a hyphen. Alternatively, the spacing for slot welds may be shown by means of a detail drawing.

Separación También, grado de inclinación. Ésto identifica la ubicación de las soldaduras. En el caso de soldaduras de tapón, se imprime esta dimensión a la derecha del símbolo de soldadura de tapón. En el caso de soldaduras de ranura, la dimensión de separación (grado de inclinación) sigue la dimensión de longitud y un guión precide la dimensión de separación. De manera alternativa, se puede mostrar la separación de soldaduras de ranura por medio de un dibujo detallado.

Steradian The Systems Internationale unit of measure for a solid angle. A steradian has its vertex in the center of a sphere and cuts off an area of the surface of the sphere equal to the area of a square having sides the same length as the radius of the sphere. For welders, this unit is most likely to be used in technical data dealing with lighting.

Esteradián La unidad de medida de un ángulo sólido del Sistema Internacional. Un esteradián tiene su vértice en el centro de una esfera y aparta un área de la superficie de la esfera igual que la área de un cuadro que tiene lados del mismo largo del radio de la esfera. Lo más probable, los soldalores utilizan esta unidad en datos técnicos relacionados con la iluminación.

Tail An optional portion of an arrow in a welding symbol. A tail is added to the symbol, only when needed, for the purpose of including a specification process or other reference.

Punta final Una porción opcional de una flecha en un símbolo de soldadura. Se agrega una punta final al símbolo, según se necesite, para poder incluir una especificación de procesamiento u otra referencia.

TYP (typical) An abbreviation used in welding symbols to indicate a repetition of identical welds. If used, it is shown in the tail of the welding symbol.

TYP (típico) Una abreviatura utilizada en los símbolos de soldadura para indicar la repetición de soldaduras idénticas. Si se utiliza, se imprime en la punta final del símbolo de soldadura.

Weld symbol Refers to that portion of the welding symbol that specifies the specific type of weld(s) required. The weld symbol is only part of the total information that may be contained in the welding symbol.

Símbolo de soldadura Se refiere a la porción del símbolo de soldadura que identifica la clase precisa de soldadura(s) requerida(s). El símbolo de soldadura es únicamente parte del total de datos que el símbolo de soldadura puede contener.

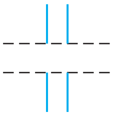
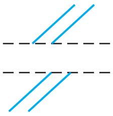
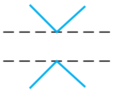
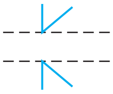
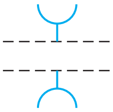
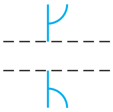
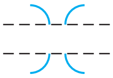
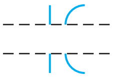
Welding symbol Refers to the total symbol, including all information added to it, to specify the weld(s) required. A standard welding symbol consists of a reference line, an arrow, and a tail.

Símbolo de soldadura Se refiere al símbolo en su totalidad, incluso todos los datos añadidos, para señalar la(s) soldadura(s) requerida(s). Un símbolo estándar de soldadura consiste de una línea de referencia, una flecha y una punta final.

APPENDIX 10

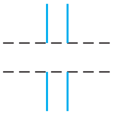
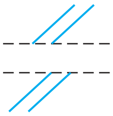
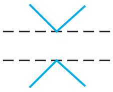
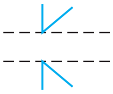
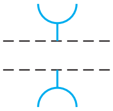
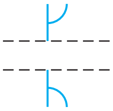
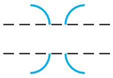
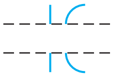
WELD SYMBOLS—ENGLISH-SPANISH INGLES-ESPAÑOL

ENGLISH

GROOVE							
SQUARE	SCARF	V	BEVEL	U	J	FLARE-V	FLARE-BEVEL
							

WELD SYMBOLS

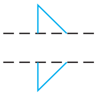
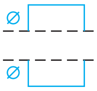
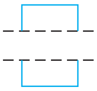
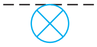
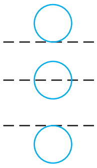
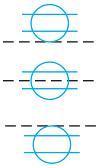
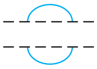
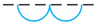
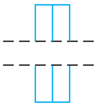
ESPAÑOL

RANURA							
CUADRADO	INCLINADO	V	CHAFLÁN	U	J	V-ACAMPANADA	CHAFLÁN-ACAMPANADO
							

SÍMBOLOS DE SOLDADURA

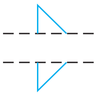
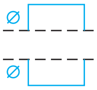
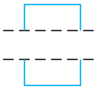
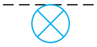
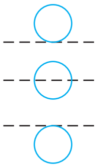
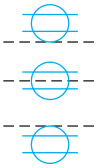
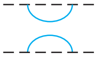
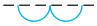
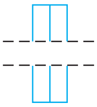
(continued)

ENGLISH

FILLET	PLUG DIAMETER	SLOT	STUD	SPOT OR PROJECTION	SEAM	BACK OR BACKING	SURFACING	EDGE
								

WELD SYMBOLS

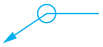
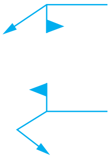
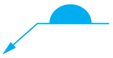
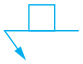
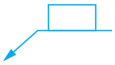
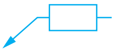
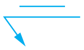
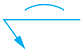
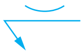
ESPAÑOL

FILETE	DIÁMETRO DEL TAPÓN	RANURA	ESPÁRRAGO	PUNTO O PROYECCIÓN	COSTURA	REVERSO O RESPALDO	LÁMINA (REVESTIDO)	BORDE
								

SIMBOLOS DE SOLDADURA

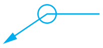
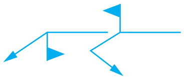
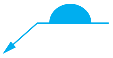
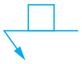
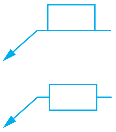
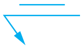
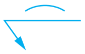
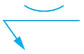
(continued)

ENGLISH

WELD-ALL-AROUND	FIELD WELD	MELT-THROUGH	CONSUMABLE INSERT (SQUARE)	BACKING (RECTANGLE)	SPACER (RECTANGLE)	CONTOUR		
						FLUSH OR FLAT	CONVEX	CONCAVE
								

SUPPLEMENTARY SYMBOLS

ESPAÑOL

SOLDAR TODO AL-REDEDOR	SOLDADURA DE CAMPO	FUNDIRSE	AÑADIDO CONSUMIBLE (CUADRADO)	RESPALDO SEPARADOR (RECTANGULAR)	CONTORNO		
					AL MISMO NIVEL O PLANO	CONVEXA	CONCAVA
							

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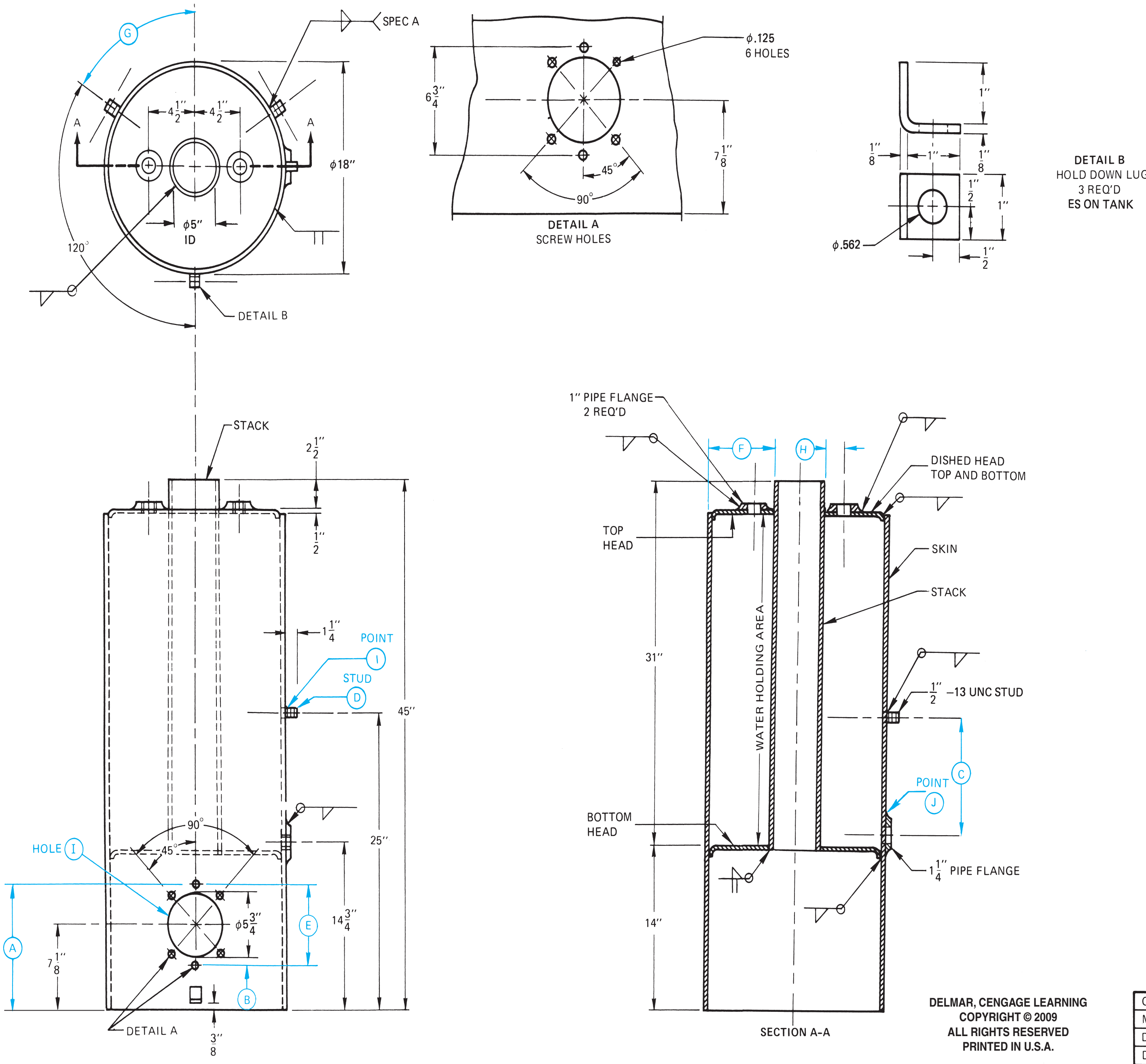
FOLDOUT 1: HOT WATER TANK



SPEC A
ALL LUGS TO BE WELDED

NOTE:
STOCK SIZES: SKIN $\frac{1}{8}''$ MS
HEADS $\frac{3}{16}''$ MS
STACK $\frac{1}{8}''$ MS

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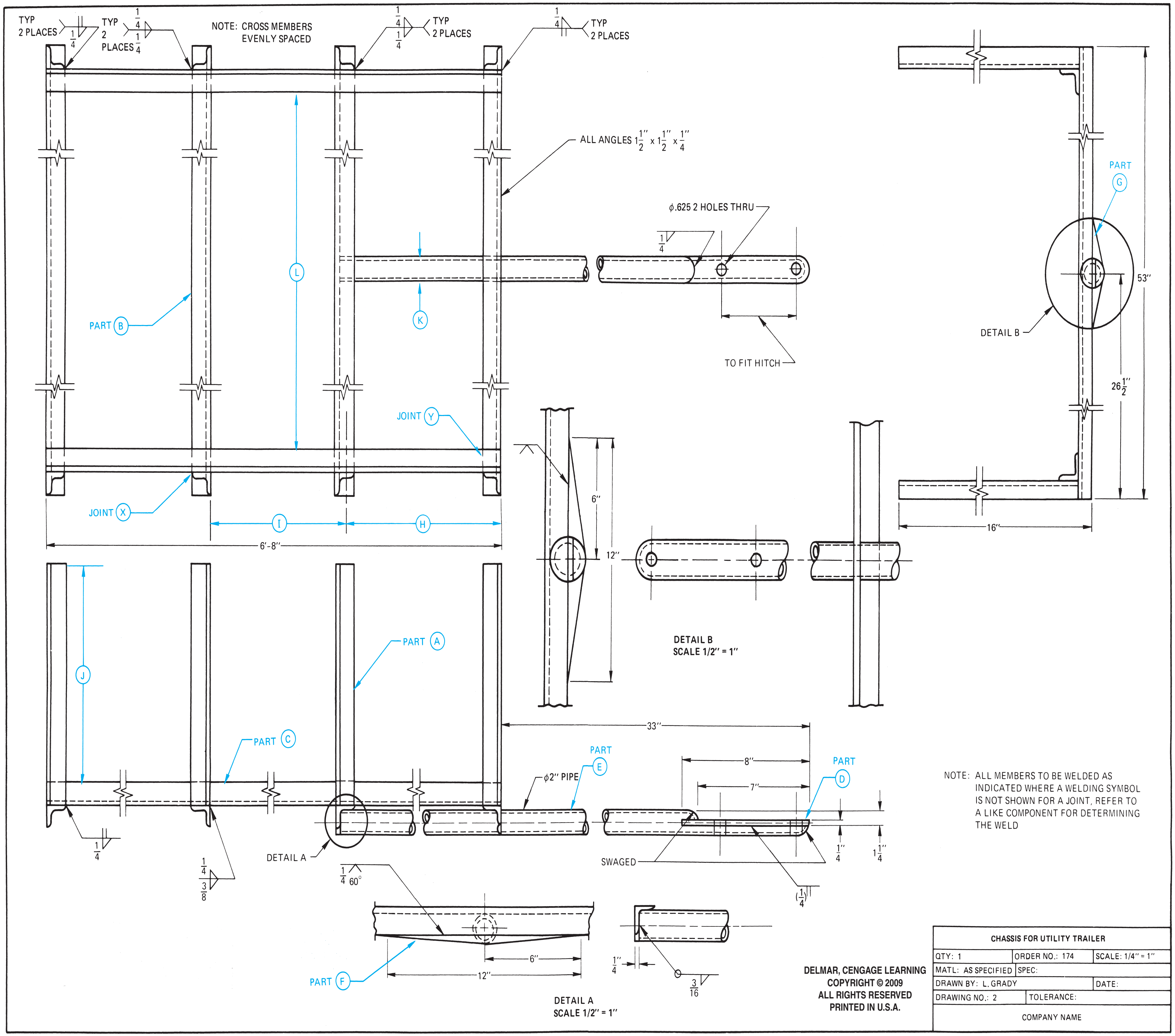
QTY. 1	ORDER NO. 86
MAT. SEE NOTE	SCALE: 1/8" = 1"
DWG. BY: L. GRADY	
DWG. NO: 3841	DATE:
HOT WATER TANK	

FOLDOUT 2: CHASSIS FOR UTILITY TRAILER



NOTE: ALL MEMBERS TO BE WELDED AS INDICATED WHERE A WELDING SYMBOL IS NOT SHOWN FOR A JOINT, REFER TO A LIKE COMPONENT FOR DETERMINING THE WELD

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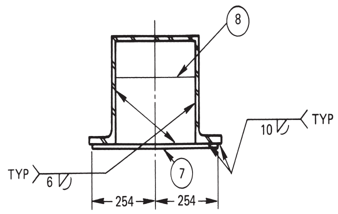
CHASSIS FOR UTILITY TRAILER

QTY: 1	ORDER NO.: 174	SCALE: 1/4" = 1"
MATL: AS SPECIFIED	SPEC:	
DRAWN BY: L. GRADY		DATE:
DRAWING NO.: 2	TOLERANCE:	

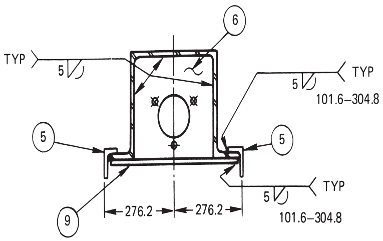
COMPANY NAME

FOLDOUT 3: CENTER SILL ASSEMBLY

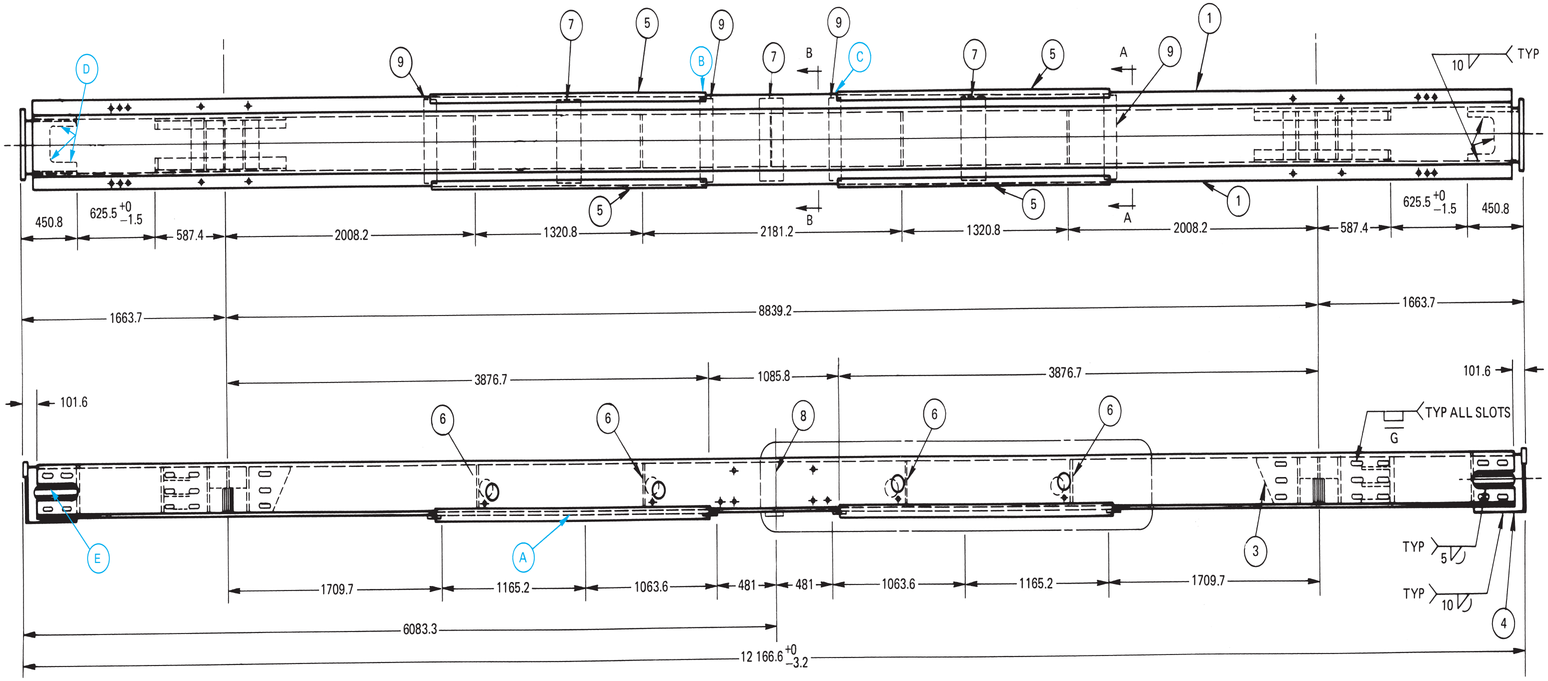
QUANT/ASSY	PART NO	DESCRIPTION	ITEM
2	2D743	CENTER SILL	1
			2
2	A4D343A	CENTER BRACE	3
2	A8D189	STRIKER	4
4	38B236B	SIDE REINFORCING	5
4	9B33	CENTER SILL SEPARATOR	6
3	9A34	CENTER SILL TIE STRAP	7
1	9A35	CENTER SILL SEPARATOR	8
4	38A262	HOPPER END CONNECTION	9



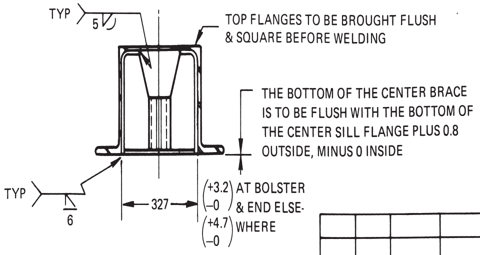
SECTION B-B



SECTION A-A



SILLS MUST BE WATERPROOF AND HAVE A MINIMUM GROOVE WELD SIZE OF 60% OF THE JOINT THICKNESS, WITH AN ULTIMATE TENSILE STRENGTH ACROSS THE WELD OF 40,000 PSI. WHERE COVER PLATE, AND SO ON, ARE TO BE APPLIED TO TOP SURFACE, THE WELD MUST BE GROUND SMOOTH. WHERE THE CENTER SILL SECTIONS ARE AUTOMATICALLY WELDED, THE GROOVE WELD SIZE IS TO BE A MINIMUM OF 75%. AT BOLSTERS, THE GROOVE WELD SIZE IS TO BE 100% FOR A MINIMUM DISTANCE OF 609.6 ON EACH SIDE OF BOLSTER CENTER LINE.



TOP FLANGES TO BE BROUGHT FLUSH & SQUARE BEFORE WELDING

THE BOTTOM OF THE CENTER BRACE IS TO BE FLUSH WITH THE BOTTOM OF THE CENTER SILL FLANGE PLUS 0.8 OUTSIDE, MINUS 0 INSIDE

(+3.2 −0) AT BOLSTER & END ELSE-(+4.7 −0) WHERE

NOTE:
ALL DIMENSIONS ARE IN MILLIMETERS (mm) ROUNDED OFF TO ONE DECIMAL PLACE

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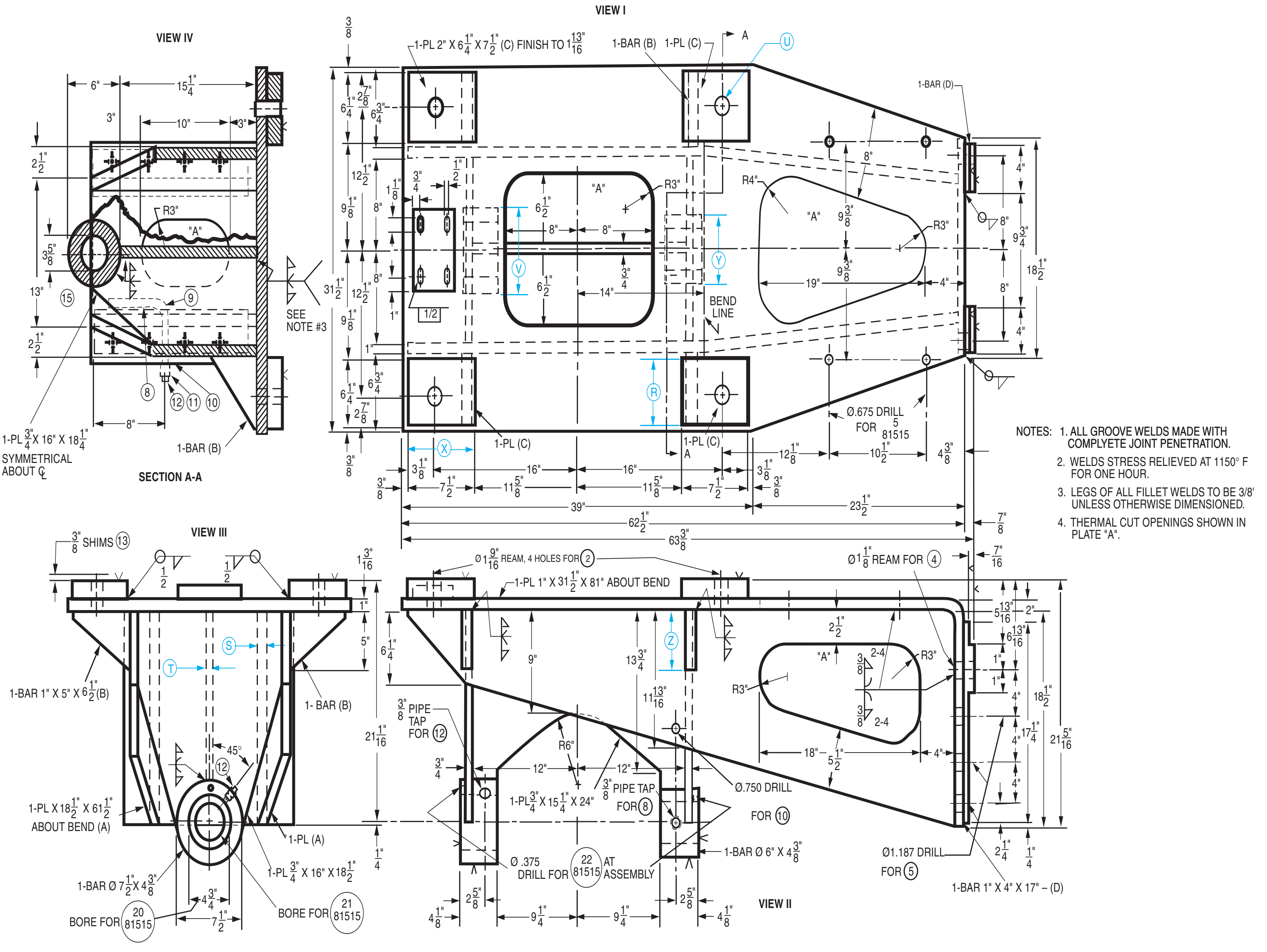
CENTER SILL ASSEMBLY		
REF. DWG. A2D664	PREPARED BY ℓQE	CHECKED BY D. R.
CORRECT		APPROVED
SCALE 3/4″ = 1′-0″	DRAWING	
DATE	A2D744	

REV	BY	DATE	REVISION
A			ITEM 1 WAS 1 PER ASS'Y & ITEM 2 REMOVED

FOLDOUT 4: TWO TROLLEYS FOR 2O TON ORE BRIDGE TROLLEY DRIVE MOTOR SUPPORT FRAME



NOTES:
1. ALL GROOVE WELDS MADE WITH COMPLYETE JOINT PENETRATION.
2. WELDS STRESS RELIEVED AT 1150° F FOR ONE HOUR.
3. LEGS OF ALL FILLET WELDS TO BE 3/8" UNLESS OTHERWISE DIMENSIONED.
4. THERMAL CUT OPENINGS SHOWN IN PLATE "A".

NO.	PARTS REQUIRED	IT.	PAT NO.	MAT'L.	NO.	PARTS REQUIRED	IT.	PAT NO.	MAT'L.	NO.	PARTS REQUIRED	IT.	PAT. NO.	MAT'L.
8	MOTOR SUPPORT FRAME	1	WELD CONSTR.	ANN. ST'L.	8	3/8" X 90° ELBOW	9		PIPE	1	6" DIA X 4 3/8"	16		A. ST'L.
					8	3/8" PIPE X 4 LG	10		"	1	7 1/2" DIA X 4 3/8"	17		"
32	1 9/16" X 7 1/4" HEX NUT	2	F525A	"	8	3/8" PIPE COUPLYING	11		"	2	BAR 1" X 4" X 5 1/4"	18		"
32	1 1/2" CP HEX NUT	3	FOR ②	"	16	3/8" ALEM. 1714 FITTING	12			4	BAR 1" X 5" X 6 1/2"	19		"
16	1 1/2" X 4 1/2" FIN BOLT	4	F525	"	32	SETS OF SHIMS EACH SET CONSISTING 2–1/16"THICK 2–1/32" THICK	13		ST'L.	4	BAR 2" X 6 1/4" X 7 1/2"	20		"
48	1 1/8" X 3 5/8" SQ HD BOLT	5		"						1	PL 3/4" X 15 1/4" X 24	21		"
64	1 1/8" LOCK WASHER	6	FOR ④⑤	"						2	PL 3/4" X 16 X 18 1/4"	22		"
64	1 1/8" CP HEX NUT	7	" " "	"	32	1 1/2" CP HEX CHECK NUT	14	FOR ②	ST'L.	2	PL 1" X 18 1/2" X 61 1/2"	23		"
8	3/8" PIPE X 6 7/8" LG	8		PIPE	8	3/8" X 90° STREET ELBOW	15		PIPE	1	PL 1" X 31-1/2" X 6'–9"	24		"

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DRAWN BY: L.J. SIY
SCALE: 1/8" = 1"

TWO TROLLEYS FOR 20 TON
ORE BRIDGE TROLLEY DRIVE
MOTOR SUPPORT FRAME

FOLDOUT 5: MOLD POSITIONER

COMPREHENSIVE REVIEW

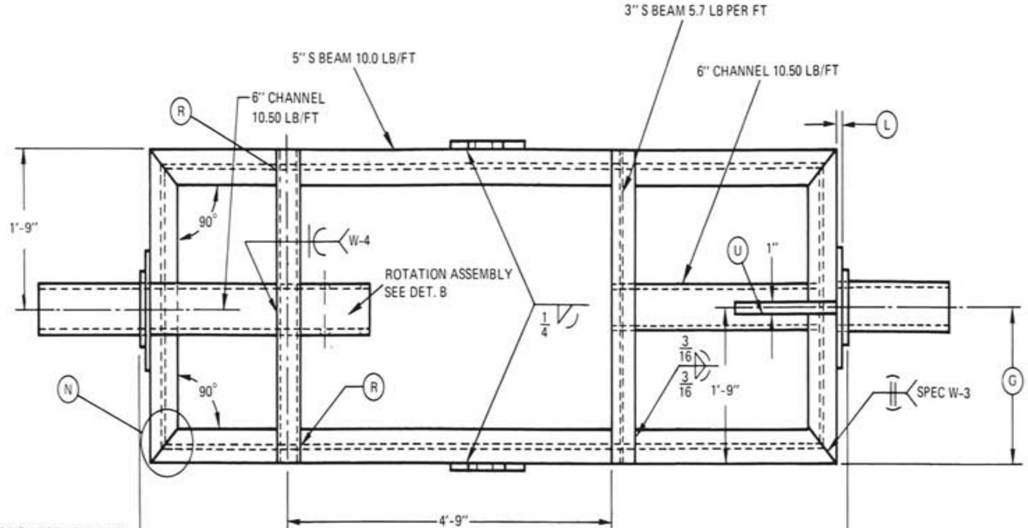
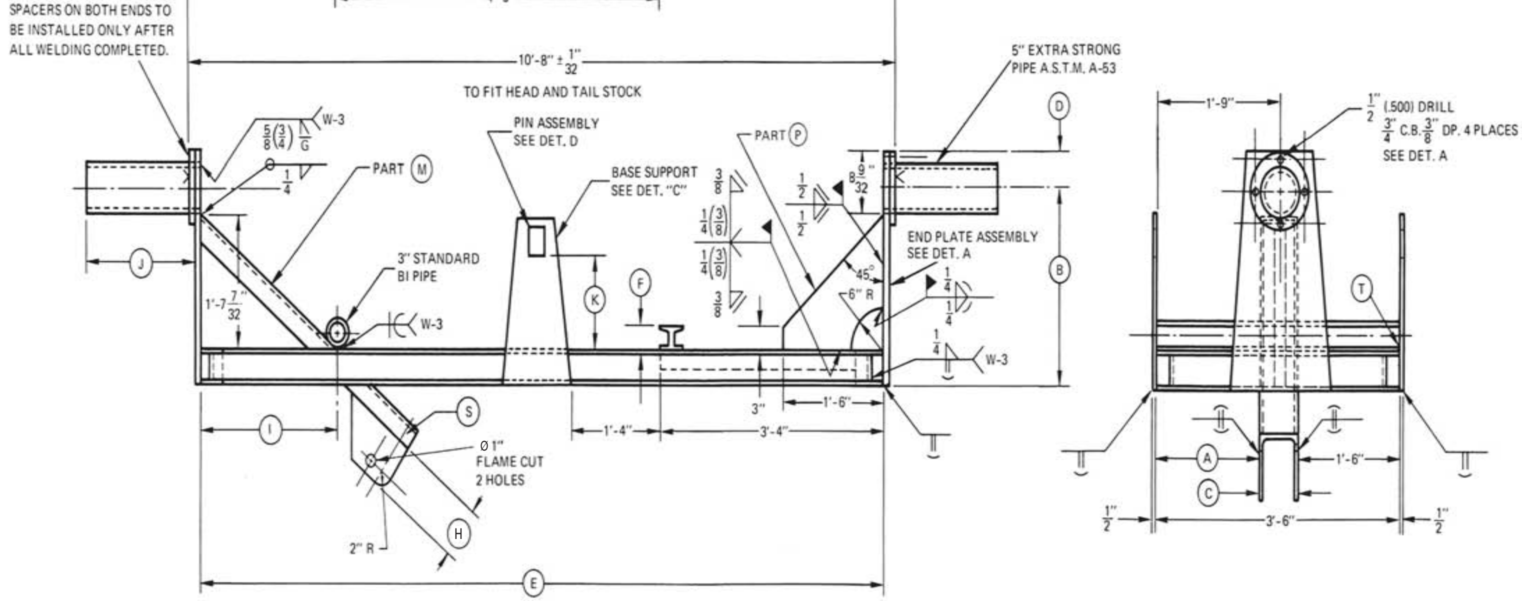


TABLE OF CONVERSIONS FOR MOLD POSITIONER, ASSEMBLY DRAWING			
FEET AND INCHES	MILLIMETER	FEET AND INCHES	MILLIMETERS
1/32"	0.8	5"	127.0
1/8"	3.2	6"	152.4
3/8"	9.5	8 3/4"	222.3
1/2"	12.7	1'-4"	406.4
5/8"	15.9	1'-6"	457.2
3/4"	19.1	1'-9"	533.4
1"	25.4	3'-4"	1016.0
2"	50.8	3'-6"	1066.8
3"	76.2	4'-9"	1447.8
		10'-8" ± 1/32"	3251 ± .8

NOTE: MILLIMETER DIMENSIONS ARE ROUNDED OFF TO NEAREST TENTH



SPACERS ON BOTH ENDS TO BE INSTALLED ONLY AFTER ALL WELDING COMPLETED.
10'-8" ± 1/32"
TO FIT HEAD AND TAIL STOCK
5" EXTRA STRONG PIPE A.S.T.M. A-53
5/8 (3/4) G
W-3
1/4
PART M
PIN ASSEMBLY SEE DET. D
PART P
D
BASE SUPPORT SEE DET. "C"
3/8
1/4 (3/8)
1/4 (3/8)
3/8
1/2
1/2
8 9/32"
END PLATE ASSEMBLY SEE DET. A
45°
6" R
1/4
1/4
B
J
1'-7 7/32"
3" STANDARD BI PIPE
W-3
K
F
1/4
W-3
3"
1'-6"
1'-4"
3'-4"
I
S
Ø 1" FLAME CUT 2 HOLES
H
2" R
E
1'-9"
1/2" (.500) DRILL 3/4" C.B. 3/8" DP. 4 PLACES SEE DET. A
T
A
C
1'-6"
1/2"
3'-6"
1/2"

W-1 COMPLETE ASSEMBLY TO BE TACK WELDED USING A.W.S. E-6011
W-2 FINAL WELDS TO BE A.W.S. E-7018 OF APPROPRIATE SIZE
W-3 SIMILAR JOINTS REQ. SIMILAR WELDS
W-4 TO BE SHOP STD.
W-5 ALL MEMBERS TO BE FLAME CUT

FILLET SIZES	
INCHES	mm
3/16	5
1/4	6
3/8	10
1/2	13

QTY.: 1 ONLY	ORDER NO. 1062
DATE: 3-6-83	DWG. NO. 0196
SCALE: 3/4" = 1'-0"	
MAT.: UNLESS OTHERWISE SPECIFIED TO BE SHOP STANDARD	
DRAWN BY: J.A.C.	
TOLERANCE: ± 1/8" UNLESS OTHERWISE NOTED	
MOLD POSITIONER (TO REPLACE PRESENT SYSTEM)	

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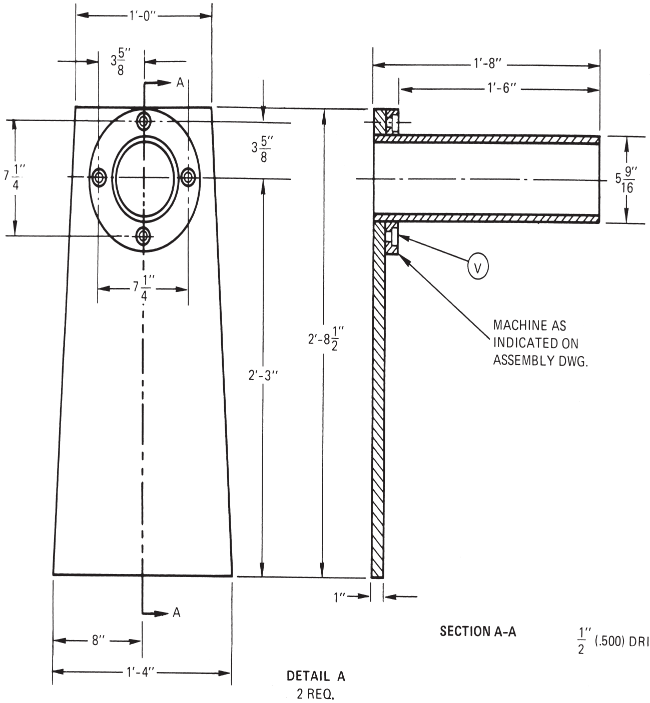
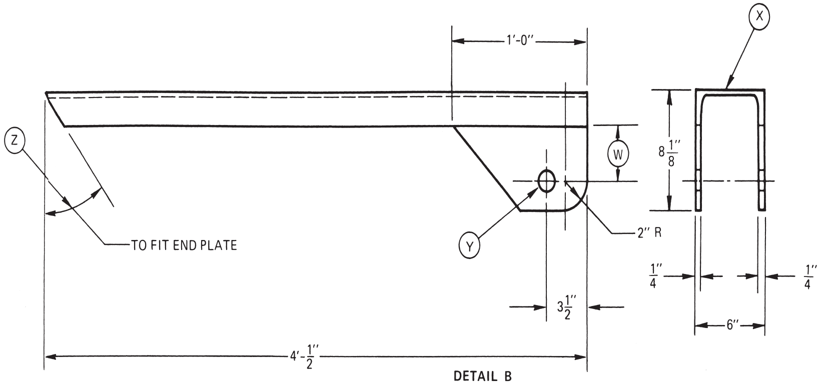
1 / 2

COMPREHENSIVE REVIEW

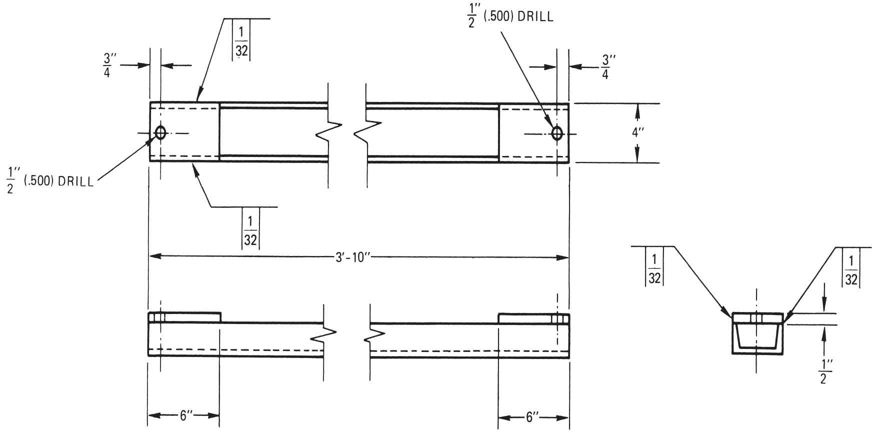


SECTION A-A

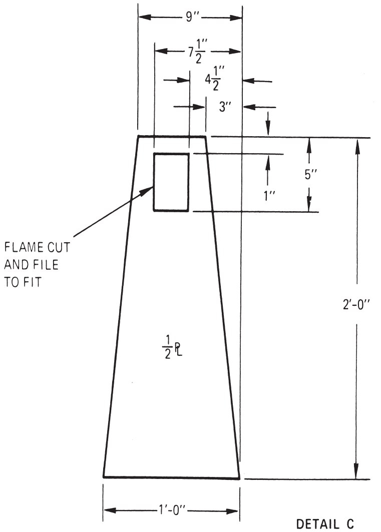
DETAIL A
2 REQ.
SCALE: NONE



DETAIL B
1 REQ.
SCALE: NONE



DETAIL D
1 REQ.
SCALE: NONE



DETAIL C
2 REQ.
SCALE: NONE

TABLE OF CONVERSIONS FOR MOLD POSITIONER, DETAIL DRAWINGS

FEET AND/OR INCHES	MILLIMETERS	FEET AND/OR INCHES	MILLIMETERS
1/32"	0.8	7 1/2"	190.5
1/2"	12.7	8"	203.2
3/4"	19.1	8 1/8"	206.4
1"	25.4	9"	228.6
2"	50.8	12"	304.8
3"	76.2	1' – 4"	406.4
3 1/2"	88.9	1' – 6"	457.2
3 5/8"	92.1	1' – 8"	508.0
4"	101.6	2' – 0"	609.6
4 1/2"	114.3	2' – 3"	685.8
5"	127.0	2' – 8 1/2"	723.9
5 9/16"	141.3	3' – 10"	1168.4
6"	152.4	4' – 1/2"	1231.9
7 1/4"	184.2		

NOTE: MILLIMETER DIMENSIONS ARE ROUNDED OFF TO NEAREST TENTH

2/2 MOLD POSITIONER

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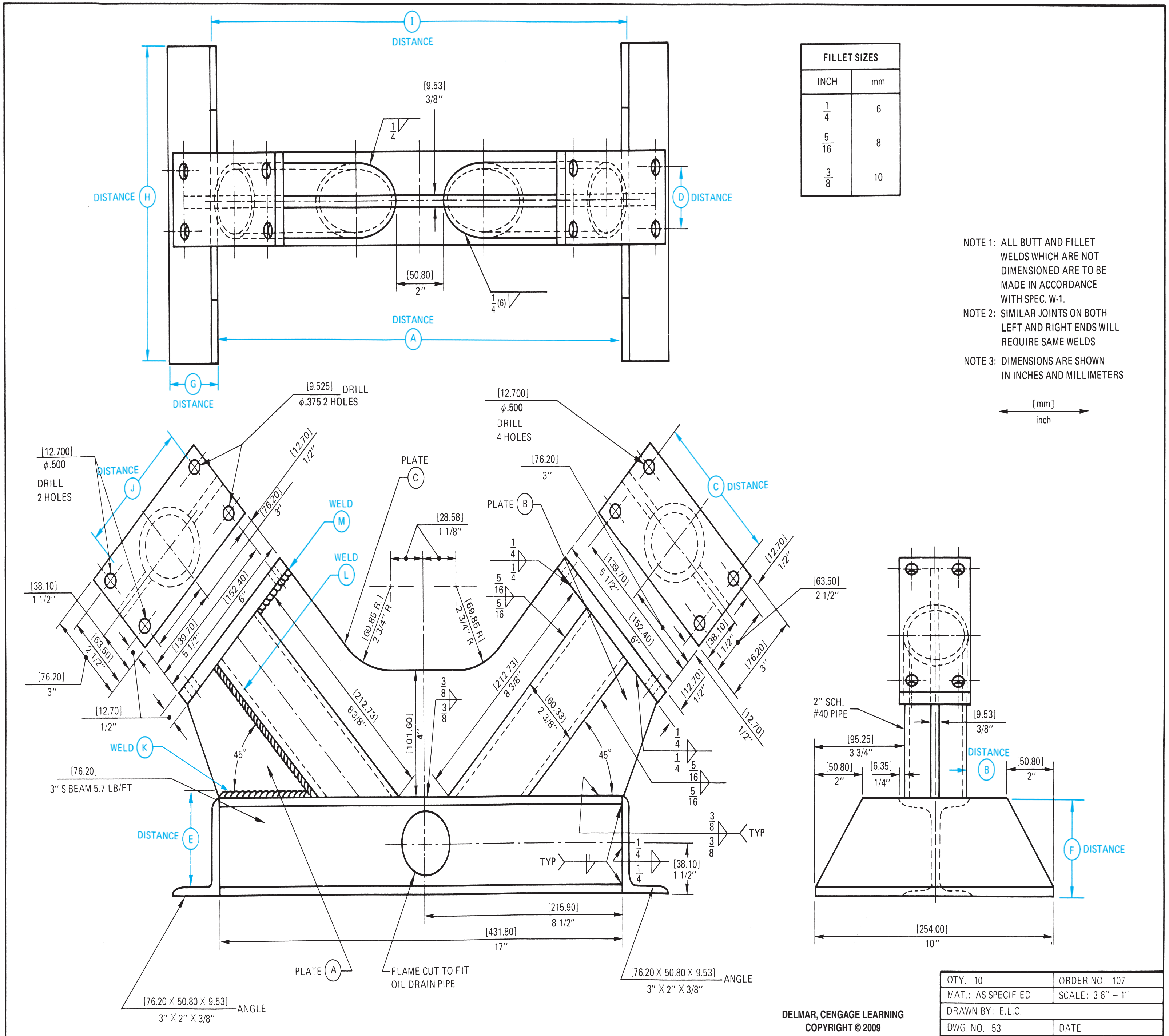

FILLET SIZES

INCH	mm
1/4	6
5/16	8
3/8	10

NOTE 1: ALL BUTT AND FILLET WELDS WHICH ARE NOT DIMENSIONED ARE TO BE MADE IN ACCORDANCE WITH SPEC. W-1.

NOTE 2: SIMILAR JOINTS ON BOTH LEFT AND RIGHT ENDS WILL REQUIRE SAME WELDS

NOTE 3: DIMENSIONS ARE SHOWN IN INCHES AND MILLIMETERS

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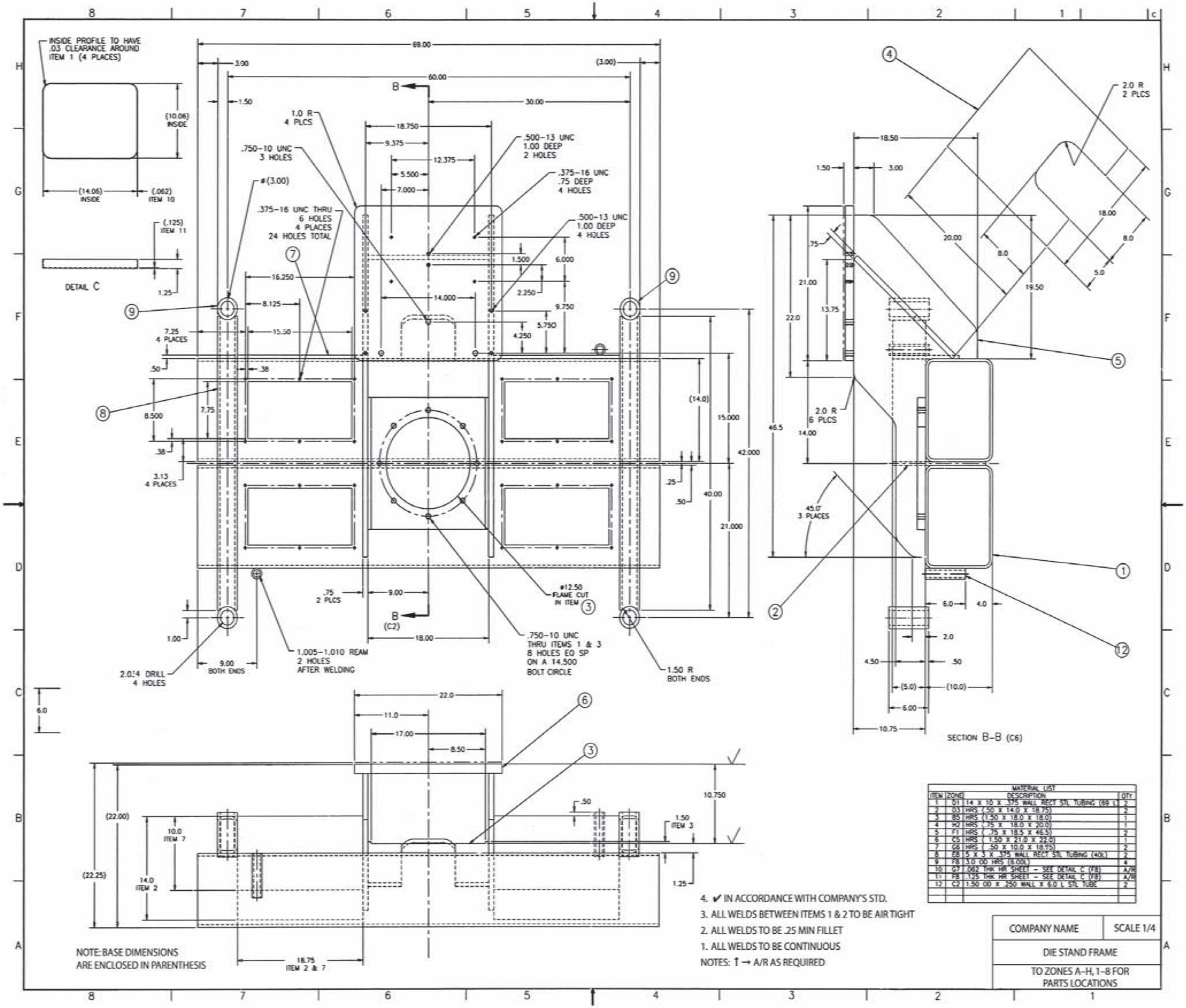
QTY. 10	ORDER NO. 107
MAT.: AS SPECIFIED	SCALE: 3 8″ = 1″
DRAWN BY: E.L.C.	
DWG. NO. 53	DATE:
ENGINE MOUNT REAR	

FOLDOUT 7: DIE STAND FRAME



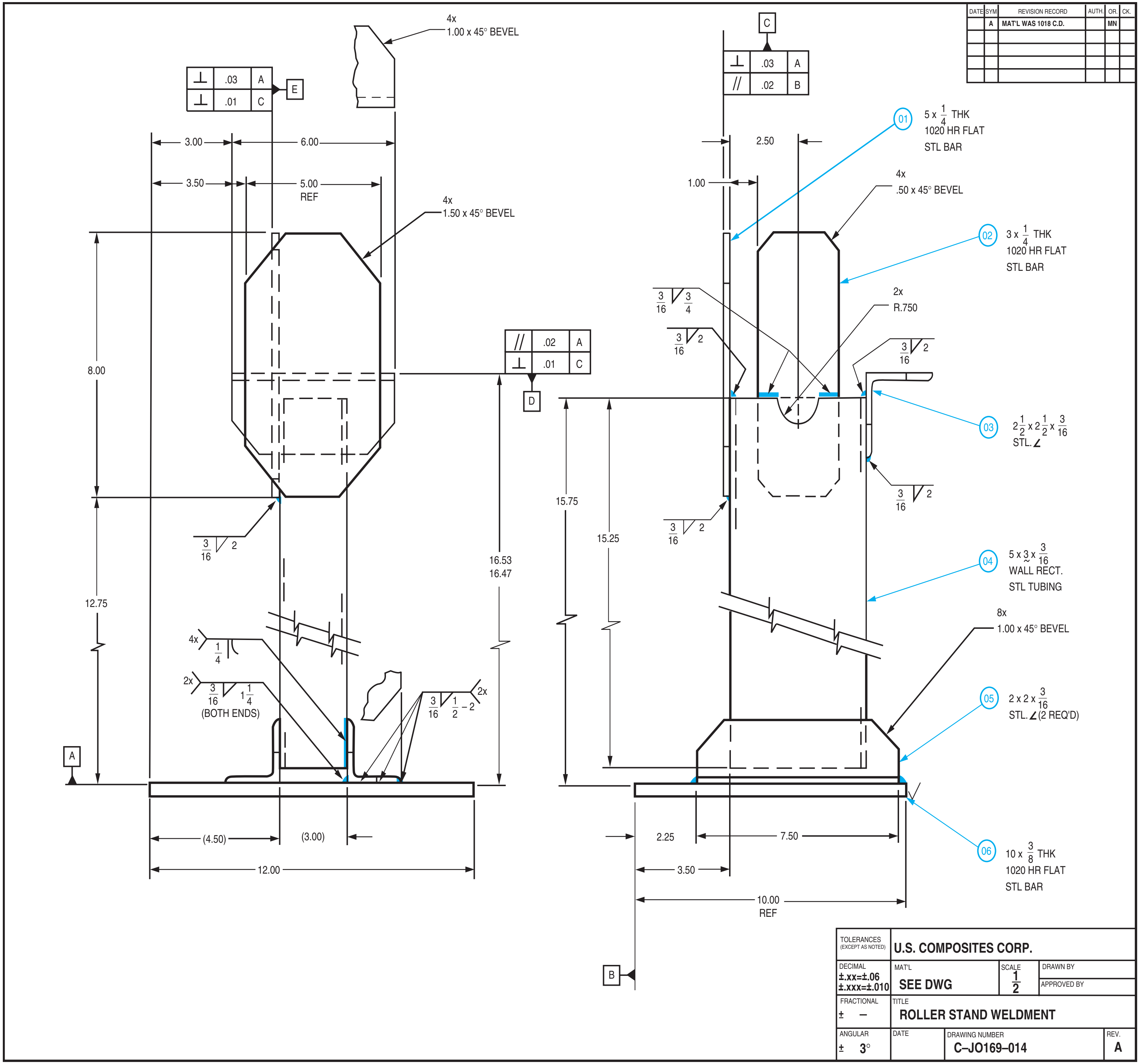
MATERIAL LIST			
ITEM	ZONE	DESCRIPTION	QTY
1	D1	14 X 10 X .375 WALL RECT STL TUBING (69 L)	2
2	D3	HRS (.50 X 14.0 X 18.75)	2
3	B5	HRS (1.50 X 18.0 X 18.0)	1
4	H2	HRS (.75 X 18.0 X 20.0)	1
5	F1	HRS (.75 X 18.5 X 46.5)	2
6	C5	HRS (1.50 X 21.0 X 22.0)	1
7	G6	HRS (.50 X 10.0 X 18.75)	2
8	E8	5 X 3 X .375 WALL RECT STL TUBING (40L)	2
9	F8	3.0 OD HRS (6.00L)	4
10	G7	.062 THK HR SHEET – SEE DETAIL C (F8)	A/R
11	F8	.125 THK HR SHEET – SEE DETAIL C (F8)	A/R
12	C2	1.50 OD X .250 WALL X 6.0 L STL TUBE	2

NOTE: BASE DIMENSIONS ARE ENCLOSED IN PARENTHESIS

4. ✔ IN ACCORDANCE WITH COMPANY'S STD.
3. ALL WELDS BETWEEN ITEMS 1 & 2 TO BE AIR TIGHT
2. ALL WELDS TO BE .25 MIN FILLET
1. ALL WELDS TO BE CONTINUOUS
NOTES: ↑→ A/R AS REQUIRED

COMPANY NAME	SCALE 1/4
DIE STAND FRAME	
TO ZONES A-H, 1-8 FOR PARTS LOCATIONS	

FOLDOUT 8: ROLLER STAND WELDMENT



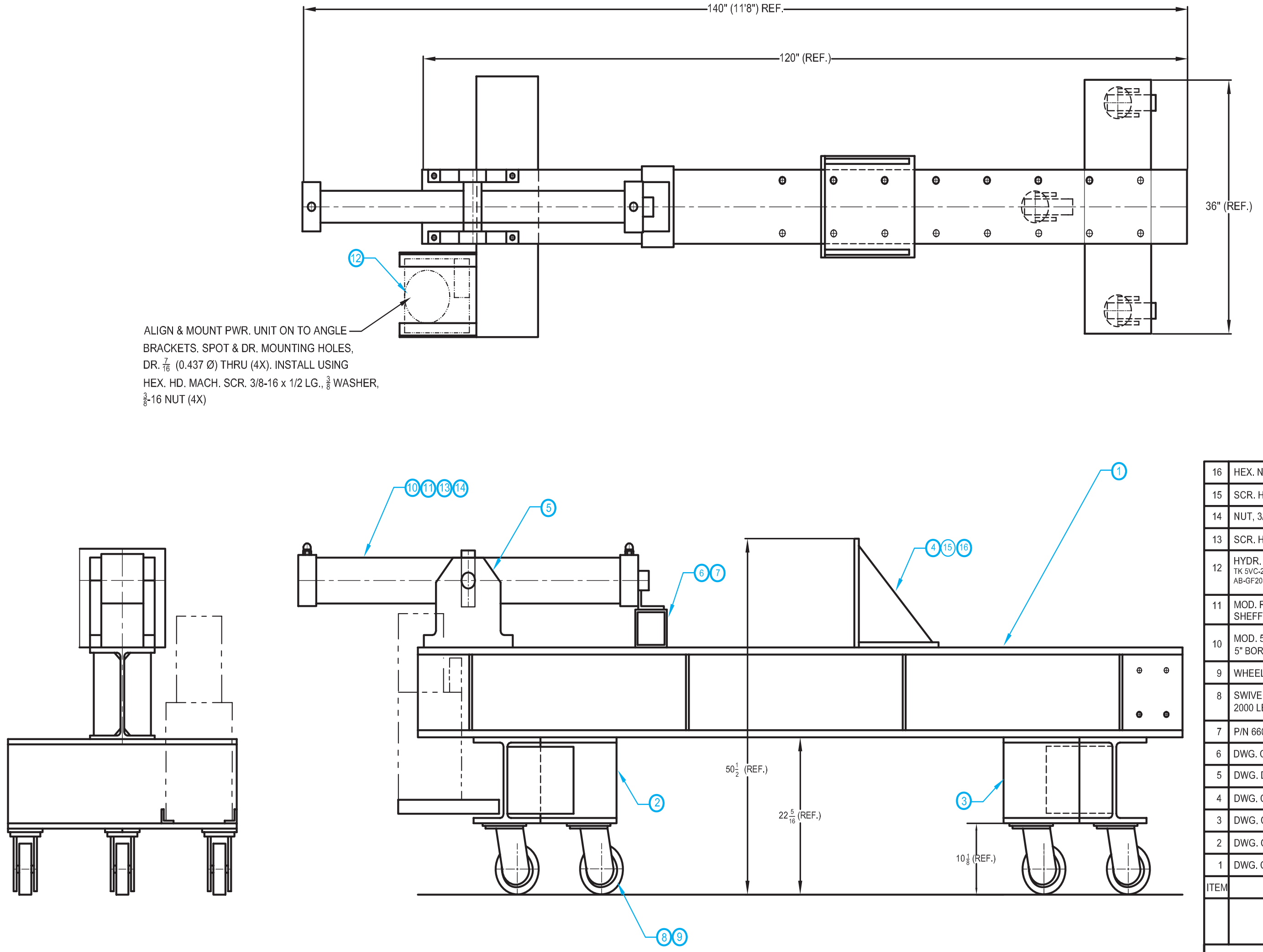
DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.
	A	MAT'L WAS 1018 C.D.		MN	

TOLERANCES (EXCEPT AS NOTED)	U.S. COMPOSITES CORP.		
DECIMAL ±.xx=±.06 ±.xxx=±.010	MAT'L SEE DWG	SCALE 1/2	DRAWN BY APPROVED BY
FRACTIONAL ± –	TITLE ROLLER STAND WELDMENT		
ANGULAR ± 3°	DATE	DRAWING NUMBER C–JO169–014	REV. A

MADE IN U.S.A.

FOLDOUT 9: MANDREL PULLER ASS'Y

DATE	SYM	REVISION RECORD	AUTH.	DRN.	CHKD.



ALIGN & MOUNT PWR. UNIT ON TO ANGLE BRACKETS. SPOT & DR. MOUNTING HOLES, DR. $\frac{7}{16}$ (0.437 Ø) THRU (4X). INSTALL USING HEX. HD. MACH. SCR. 3/8-16 x 1/2 LG., $\frac{3}{8}$ WASHER, $\frac{3}{8}$-16 NUT (4X)

16	HEX. NUT 1"-8 UNC, ALLOY STL.	4	-
15	SCR. HEX. HD. CAP 1"-8 x $3\frac{1}{2}$ LG., ST. S.A.E. GR 5	4	-
14	NUT, 3/4-10 UNC, ALLOY STL.	4	-
13	SCR. HEX. HD. CAP 3/4-10 x 4" LG., ST., S.A.E. GR 5	4	-
12	HYDR. PWR. UNIT VICKERS SYSTEM-PAK TK 5VC-20-M-PIA-S8C-FNY AB-GF20-F1-A3-WB	1	~100
11	MOD. RAC-0187 COUPLER, ROD ALIGN; SHEFFER CORP.	1	21.5
10	MOD. 5HHT 48K HYDR. CYL., S/N 1210741 5" BORE, 2 1/2" ROD, 48" STROKE; SHEFFER CORP.	1	290
9	WHEEL BRAKE; MAC-CARR P/N 2432T77	2	4
8	SWIVEL CASTERS, Ø8" PHENOLIC, 2000 LB. CAP.; MAC-CARR, P/N 2432T26	6	15
7	P/N 660-50476 FT. BRKT.; SHEFFER CORP.	1	-
6	DWG. C-T0213 PISTON END SUPPORT	1	14
5	DWG. D-T0083 MT. BLOCK-HYDR. CYL.	2	55
4	DWG. C-T0090 BRACKET	1	85
3	DWG. C-T0212-2 BEAM DOLLY	1	245
2	DWG. C-T0212-1 BEAM DOLLY	1	248
1	DWG. C-T0211 BEAM BASE	1	587
ITEM	DESCRIPTION	QTY.	EST.WT./EA.

TOLERANCES (EXCEPT AS NOTED)	U.S.COMPOSITES CORP.		
DECIMAL: ±	MATL:	SCALE: 1"–1	DRN.BY: APPD.BY:
FRACTIONAL: ±	TITLE: MANDREL PULLER ASS'Y.		
ANGULAR: ±	DATE:	DRAWING NUMBER: C-T0214	

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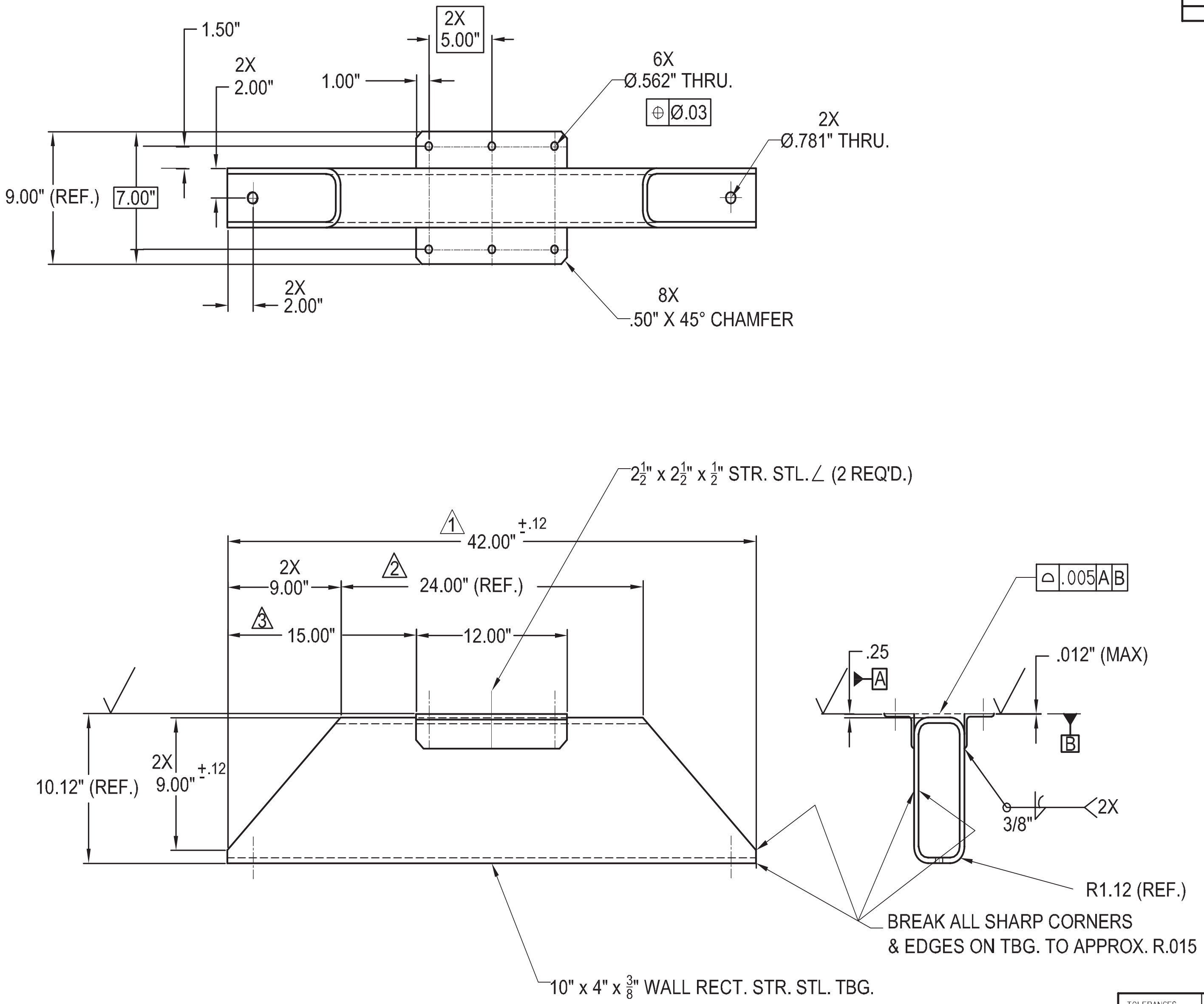
REF: APPROX. WT. 1800 lbs.

DATE	SYM	REVISION RECORD	AUTH.	DRN.	CHKD.



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TOLERANCES (EXCEPT AS NOTED)	U.S.COMPOSITES CORP.		
DECIMAL: ±.XX=±.06 ±.XXX=±.010	MATL: SEE DWG.	SCALE: 1/4	DRN.BY: APPD.BY:
FRACTIONAL: ± -	TITLE: STRONGBACK STAND		
ANGULAR: ± 5°	DATE:	DRAWING NUMBER: C-J0169-022	REV. A